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MORRIS'S

HUMAN ANATOMY

A COMPLETE SYSTEMATIC TREATISE BY ENGLISH AND AMERICAN AUTHORS

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PART II

THE MUSCULATURE. THE ORGANS OF CIRCULATION. THE LYMPHATICS

PHILADELPHIA
P. BLAKISTON'S SON & CO.
1012 WALNUT STREET
1907

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WM. F. FELL COMPANY
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1220-24 SANSOM STREET
PHILADELPHIA, PA.

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ARRANGEMENT OF SUBJECTS AND AUTHORS.

The names of those who originally wrote articles and those who revised and wrote for previous editions have been retained in the following list of contents, in order that due credit should be given them for the work done and for their share in the great success which Morris's "Anatomy" has achieved throughout England and America.

MORPHOGENESIS. (The Development of Structure.) By J. Playfair McMurrich, A.M., Ph.D., Professor of Anatomy, University of Toronto; Member Association of American Anatomists; Member of Advisory Board, Wistar Institute of Anatomy; Member of Editorial Board of "American Journal of Anatomy;" Author of "The Development of the Human Body."

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HEART, BLOOD-VESSELS, AND LYMPHATICS. Revised and in part rewritten by Florence R. Sabin, B.S., M.D., Associate Professor of Anatomy in the Johns Hopkins University; Member Association of American Anatomists. The section on Blood-vessels was originally written by the late William J. Walsham, F.R.C.S., formerly Lecturer on Anatomy, St. Bartholomew's Hospital, London. The section on the Heart in previous editions was written by the late Arthur Hensman, F.R.C.S., and revised by Arthur Robinson, M.D., Professor of Anatomy, University of Birmingham.

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THE DUCTLESS GLANDS, INCLUDING THE THYREOID GLAND. By G. Carl Huber, M.D., Professor of Histology and Embryology in the University of Michigan; Secretary Association of American Anatomists.

THE SKIN AND MAMMARY GLAND. By Abram T. Kerr, B.S., M.D., Professor of Anatomy, Cornell University; Member Association of American Anatomists, etc. This article was originally written by the late William Anderson, F.R.C.S., formerly Vice-President Anatomical Society of Great Britain.

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ABSTRACT OF PUBLISHERS' NOTE

AS PRINTED IN PART I

The very favorable reception accorded the previous editions of this work in America suggested the desirability of making the present (fourth) edition international in its character, by placing it largely in the hands of an American editor and by securing the services of American Anatomists in the revision or rewriting of certain of the sections.

The entire work has undergone a complete revision, and some sections have been entirely rewritten and, in several instances, considerably enlarged; the text has been brought thoroughly up to date by the inclusion of the results of recent investigations, and represents, accurately, the present state of Anatomy. Many illustrations which appeared in previous editions have been omitted, a large number of new figures have been made from specially prepared drawings, and pictures from other books have been included where they served the desired purpose.

Special attention should be directed to the use throughout the volume of the nomenclature adopted by the German Anatomical Society and generally known as the Basle nomenclature, or BNA. In employing this nomenclature the editors have been guided by a desire to assist in the unification of anatomical terminology, seeing in such unification an earnest of the thorough internationalization of the science of anatomy and more rapid progress in its development. The modifications of the accepted English nomenclature necessitated by the adoption of the BNA are comparatively few, and where they are radical, the more familiar terms have been added in parentheses. Whilst this is the first text-book of Anatomy in English to adopt the BNA in its entirety, there are a number of books and papers on Embryology, Histology, and Biology in which it is used; its general adoption in the future, it may be confidently expected, will be assured. In this connection, reference should be made to a new book by Prof. Llewellys F. Barker, of Johns Hopkins University, in which a complete list of the terms used in the BNA is given and in which the object, system, and practicability of the nomenclature are explained.

Each author is alone responsible for the subject-matter of the article following his name. Care has been exercised on the part of the editors, however, to make the whole uniform, complete, and systematic.

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Originally Written by J. N. C. Davis-Colley, F.R.C.S.

Revised and Largely Rewritten for Fourth Edition by C. R. Bardeen, A.B., M.D.

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Revised and Largely Rewritten for Fourth Edition by Florence R. Sabin, B.S., M.D.

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The mode of describing illustrations which has been carried out as far as practicable consists in printing the descriptions in different types at the end of the pointers. Thus, the **muscles, fasciæ, and ligaments** are in one kind of type ; ***arteries, veins, and lymphatics*** in another ; BONES AND SPECIAL ORGANS in a third ; ***NERVE STRUCTURES*** in a fourth.

SECTION IV

THE MUSCULATURE

ORIGINALLY WRITTEN BY J. N. C. DAVIS-COLLEY, F. R. C. S. REVISED AND LARGELY REWRITTEN BY

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MUSCLES, the movements of which are under the control of the will, almost completely envelope the skeletal framework of the body; close in the oral, abdominal, and pelvic cavities; separate the thoracic from the abdominal cavity; surround the upper portion of the pharynx; and are found connected with the eye, ear, larynx, and other organs. They constitute about two-fifths to three-sevenths of the weight of the body.

In this section an account is given of the gross anatomy of the musculature attached to the skeleton and the skin, with the exception of certain of the muscles which are more conveniently treated in connection with the organs to which they are appended. Thus, the muscles of the eye, the ear, the pharynx, the larynx, the perineum, and the uro-genital organs, and the intrinsic muscles of the tongue are described in the sections devoted to those structures.

Relations to the skin.—Beneath the skin is a sheet of connective tissue, the **tela subcutanea.** In this, in some regions of the body (the head, neck, and palm), thin, flat, **subcutaneous muscles** are embedded. Superficial muscles of this kind constitute a **panniculus carnosus,** much more extensive in the lower mammals than in man. The tela subcutanea is separated from the more deeply seated musculature by areolar tissue, which, in most places, is loose in texture over the muscles. In some regions, as over the upper part of the back, the tela subcutanea is firmly united to the underlying musculature and is less freely movable. In the tela subcutanea more or less fat is usually embedded. This constitutes the **panniculus adiposus,** which varies greatly in thickness in different parts of the body. As a rule, it is much more developed over muscles than over those regions where bone and joints lie beneath the skin. From the tela subcutanea of the eyelids, penis, and scrotum fat is absent. The deeper layer of the tela subcutanea is more or less free from fat, and in it run the main trunks of the cutaneous nerves and vessels. In some regions, as over the lower part of the abdomen, one or more fibrous membranes are differentiated in this deeper layer.

To the tela subcutanea the term **superficial fascia** has been commonly applied, but since this leads to a confusion with the superficial fasciæ which immediately invest the muscles, it seems better to restrict the term fascia to the membranes connected with the muscular system, and to use the term **tela subcutanea** for the layer of connective tissue which underlies the skin and is continuous over the whole surface of the body.

In several places where the skin overlies bony prominences well-marked **synovial bursæ,** or sacs (**bursæ mucosæ**), are developed in the tela subcutanea.

Since the skin and the subcutaneous tissue must be removed in order to study the muscles of various regions, the tela subcutanea and subcutaneous bursæ may be conveniently described in connection with the muscles, and brief references will, therefore, be made to them in connection with the musculature of various regions.

Muscle fasciæ.—The musculature of the body, with the exception of some of the subcutaneous muscles, is ensheathed by membranous tissue, which, in certain regions, is thick and strong, in others much more delicate. These membranes, or **muscle fasciæ,** are united to various parts of the skeleton, either directly or by means of intermuscular septa, and, where strong, serve to keep the underlying musculature in place. In some areas they are united to the muscles; in others they are separated from the underlying musculature by loose areolar tissue, which allows free movement between the surface of the muscles and the overlying fascia. The best example of a strong fascia of this nature is that which envelopes the extensor muscles of the thigh. Where the fasciæ are well developed, the main bundles of constituent fibres take a course directly or obliquely transverse to the direction of the underlying muscles. They may be composed of several successive layers of fibrous tissue, the fibres of one layer taking a different direction from those of the next layer.

Intermuscular septa.—Muscle fasciæ serve to enclose not only the external layer of the musculature of the body, but also the various groups of more deeply seated muscles. In addition, between the individual muscles, and between the different layers and groups of muscles, there intervenes a greater or less amount of connective tissue, sometimes loose in texture, sometimes dense in structure. In these intermuscular septa run the chief nerves and blood-vessels of the region in which the musculature lies.

Gross structure of the muscles.—The muscles are composed of bundles of reddish fibres surrounded by a greater or less extent of white and glistening connective tissue. They are attached by prolongations of this tissue in the form of **tendons** or **aponeuroses** usually to the bony skeleton, but also in places to cartilages, as on the thorax and larynx; to the skin, as in the face; to mucous membranes, as in the tongue and cheeks; to the tendons of other muscles, as in the case of the lumbrical muscles; to muscle fasciæ, as in the case of the oblique and transverse muscles of the abdomen; and to other structures, as, for instance, to the eyeball.

The fleshy portion of the muscle is called the **belly.** The belly is usually attached at one extremity to a portion of the skeleton or to some other structure which serves as a support for its action on the structures to which its other extremity is attached. The attachment to the more fixed part is called the **origin** of the muscle; the attachment to the structure chiefly acted on is called the **insertion.** Thus the origin of the biceps muscle, the chief flexor of the forearm at the elbow, is from the scapula; the insertion is into the radius and into the fascia of the forearm. The part of the muscle attached to the origin is called the **head** of the muscle. The part attached to the insertion is sometimes called the **tail,** but this term is much less frequently used than the former.

The muscles vary greatly in **size** and **form.** Thus the stapedius muscle of the middle ear is a slender little structure, only a few millimetres long, while the gluteus maximus muscle of the hip is a large, rhomboid structure often several centimetres thick and with a surface area of over 500 square centimetres. The length of muscle from origin to insertion may be much less than the width of the muscle, as in the intercostal muscles; or much greater than the width, as in most of the long muscles of the limbs. The thickness of a muscle is usually less than the width—so much so in some instances that the muscle is described as flat, sheet-like, or ribbon-like; while in other instances the belly is cylindrical. In flat muscles the general outline is usually quadrilateral or triangular. In triangular muscles in most instances one angle of the triangle marks the insertion of the muscle, while the opposite side marks the origin. In cylindrical muscles the belly usually has a somewhat fusiform shape, and contracts both towards the origin and the insertion of the muscle.

Some muscles are divided by tendons transverse to the long axis of the muscle. When one such tendon exists, the muscle is called **digastric** (fig. 312); when several, **polygastric,** e. g., rectus abdominis (fig. 349).

Two muscle masses with separate origins may have a common insertion. Such muscles are usually designated **bicipital** muscles (biceps muscles of the **arm** and thigh). Other muscles have three heads (the triceps muscle of the arm) or four (the quadriceps muscle of the thigh). In the latter case special names are given to the four parts or muscles which constitute the quadriceps as a whole. In addition to these comparatively simple compound muscles there are others in which the various component fasciculi and the tendons of origin and insertion are numerous and complexly interrelated. The intrinsic muscles of the back offer good illustrations of muscles of this nature.

In addition to muscles with distinct regions of origin and insertion, there are a few voluntary muscles which surround hollow viscera or their orifices and have a circular or tube-like form (sphincter muscles, voluntary muscles of the œsophagus, etc.).

Number of muscles.—A logical constancy does not appear always to have been followed in the commonly accepted division of the musculature into muscles individually designated. Most of the muscles are symmetrically placed in pairs, one on each side of the body. Authors not only vary in the extent to which they carry the subdivisions of the musculature on each side of the body into individual muscles, but also in describing muscles placed near the median line either as single muscles with bilateral halves or as paired muscles. In addition some muscles are not constantly present, and there are differences of opinion as to which of these less constant muscles should be classed with the normal musculature. Thus Sappey recognises 501 muscles, distributed as follows:—trunk, 190; head, 63; arms, 98; legs, 104; and alimentary canal, 46. G. D. Thane finds 311 muscles on each side of the body:—head and front of neck, 82; vertebral column and back of neck, 60; thorax, 42; abdomen, 14; arm, 59; leg, 54.

Finer structure of muscles.—While no attempt can be made here to describe in detail the finer microscopic features of muscle structure, some of the more general features of muscle architecture may be briefly mentioned.

The contractile cells of voluntary muscle are long, slender, multinucleated **'fibres,'** the protoplasm of which exhibits both cross and longitudinal striation. The length of these fibres in the human body varies from a few millimetres to sixteen centimetres or more, and the thickness from thirty to sixty-five microns. Each muscle-fibre is surrounded by an especially differentiated sheath, the **sarcolemma.** Outside of this is a layer of delicate connective tissue, the **perimysium internum** or **endomysium,** the fibres of which are in part inserted into the sarcolemma. This connective tissue, which is especially developed at the ends of the fibres, serves to attach them either directly to the structures on which the muscle acts or to the skeletal framework of the muscle.

In the simplest mammalian muscles the muscle-fibres take a parallel course from tendon to tendon, and are not definitely bound into secondary groups. An example may be seen in fig. 304, a, which represents two segments of the rectus abdominis muscle of a mouse. More often, however, the individual fibres do not run the entire distance from tendon to tendon, but instead they interdigitate, and the interdigitating fibres are bound up into secondary and tertiary anastomosing fibre-bundles by connective tissue. Fig. 304, b, represents diagrammatically this interdigitation of fibre-bundles as seen in the abdominal musculature of one of the larger mammals.

In most of the flat muscles of the body the fibre-bundles either take a nearly parallel course from tendon to tendon or they converge from the tendon of origin towards the tendon of insertion (see fig. 304, c–e). The greater the distance from tendon to tendon, the more marked is the interdigitation of the constituent muscle-fibres.

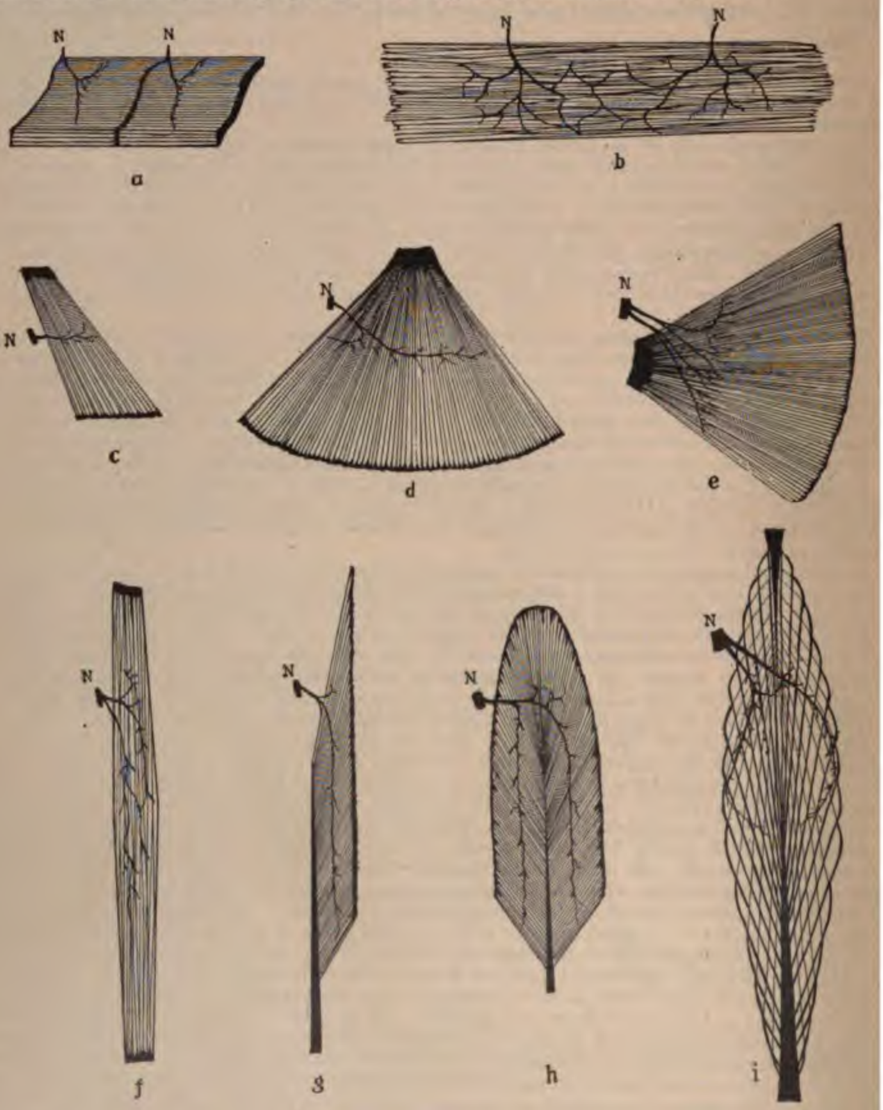
In elongated muscles the tendons of origin and insertion may either arise near the extremities of the muscle or may extend for a considerable distance on the surface or within the substance of the muscle. In the former case the belly of the muscle is composed of bundles of interdigitating fibres which take a course parallel with the long axis of the muscle. This is shown diagrammatically in fig. 304, f. An example may be seen in the sartorius muscle of the thigh (fig. 358). When the tendons extend far on the surface or within the substance of the muscle, the constituent fibre-bundles take a course oblique to the long axis of the muscle. When they take a course from a tendon of origin on one side towards a tendon of insertion on the other, the muscle is called **unipenniform** (see fig. 304, g, and the extensor digitorum longus, fig. 362). In other instances the fibre-bundles converge from two sides towards a central tendon. Such a muscle is called **bipenniform** (see fig. 304, h, and the flexor hallucis longus, fig. 364). When there are several tendons in the muscle between which the fibre-bundles run obliquely, the muscle is called **multipenniform.** In **fusiform** muscles the tendons usually either embrace the extremity of the muscle like a hollow cone, or they extend far on the surface or within the substance of the muscle. In such muscles the fibre-bundles take a curved course from one tendon to the other. The bundles which arise highest on one tendon are inserted highest on the other, and the fibre-bundles of lowest origin have the lowest insertion. This structure is diagrammatically shown in fig. 304, i. A good example may be found in the rectus femoris muscle (fig. 358).

Many other arrangements of the fibre-bundles are found, and the arrangements here shown may be most variously combined. In most muscles the architecture is decidedly complex. In the more complex muscles dense connective-tissue septa, or intramuscular fasciæ, serve to separate different regions of the muscle from one another. In general there are groups of muscle fibre-bundles surrounded by a greater amount of connective tissue, or perimysium internum, than that surrounding the individual fibre-bundles, and the latter are surrounded by a denser connective tissue than that surrounding the component muscle-fibres. The muscles are surrounded externally by a more or less dense sheet of connective tissue called the perimysium externum, or epimysium, which is continuous with the connective tissue within the muscle, the perimysium internum. In the following pages 'muscle fibre-bundle' is used to denote small groups of muscle-fibres, 'fasciculus' to denote large, more or less isolated, groups of fibre-bundles.

Tendons.—Muscles vary not only in general form and in the relations of the constituent fibre-bundles to the intrinsic skeletal framework, but also in the mode of attachment to the parts on which they act. In many instances the fib bundles impinge, perpendicularly or obliquely, directly upon a bone or cartila The connective tissue surrounding the fibre-bundles of the muscle here is attach to the periosteum or perichondrium. A broad attachment is thus offered the mus Instances of this mode of attachment may be seen in the attachment of the int costal muscles and of many of the muscles attached to the shoulder and hip girdl

Fig. 304.—Diagrammatic Outlines to illustrate Various Types of Muscle Architect and the Relations of the Main Nerve Branches to the Fibre-bundles of the Muscle

a. Two segments of the rectus abdominis muscle of a small mammal. b. Portion of sheet- muscle with two nerve-branches and intramuscular nerve plexus. c. Typical quadrilat muscle with nerve passing across the muscle about midway between the tendons. d an Two triangular muscles with different types of innervation. f. Long ribbon-like mu with interdigitating fibre-bundles. g. Unipenniform muscle. h. Bipenniform mus i. Typical fusiform muscle. The main intramuscular nerve-branches are distributed to fibre-bundles about midway between their origins and insertions. N. nerve.



In the case of most thin, flat muscles the muscle is continued at one or b extremities into thin, tendinous sheets called **aponeuroses**, composed of connect tissue. Well-marked instances may be seen in the transverse muscle of the abdom (fig. 351), and the trapezius and latissimus dorsi muscles of the back (fig. 318). T extent of development of these aponeuroses is generally inversely proportional to the development of the muscle—the more extensively developed the muscle is in a given individual, the less extensive the aponeurotic sheet.*

Most muscles are continued at one or both extremities into dense, tendinous bands which may be comparatively short and thick, like the tendon of Achilles (fig. 360), or very long and narrow, like the tendon of the palmaris longus (fig. 331). In this latter case the tendon represents in part the remnants of musculature more highly developed in the lower vertebrates. In most instances, however, the tendons are structures specifically differentiated for definite functions.

In some tendons **sesamoid bones** are developed in the neighbourhood of joints over which the tendons pass. Examples of these are the patella at the knee-joint (fig. 359) and the sesamoid bones of the thumb and great toe.

Where muscles or tendons closely envelope a joint, there is usually formed a close union between the connective tissue of the capsule of the joint and that of the muscle or the tendon.

Where tendons run for some distance across or beneath a fascia, they are usually either bound to the fascia by a special investment, as near the wrist and knee (fig. 327 and fig. 361), or are fused with the fascia, as in the case of the ilio-tibial band (p. 431).

Often in broad aponeurotic attachments of muscles there is formed in the tendon near its insertion a fibrous archway (**arcus tendineus**) for the passage of blood-vessels, nerves, muscles, or tendons. The tendinous arch is either fastened at both ends to the bone, or at one end it is connected with a joint capsule. The dorsal attachment of the diaphragm (fig. 352) and that of the adductor magnus to the femur (fig. 356) offer good examples of tendon arches.

In digastric and polygastric muscles the transverse tendons which separate the bellies are often composed of narrow, incomplete bands of fibrous tissue. Such a transverse band is called an **inscriptio tendinea** (see RECTUS ABDOMINIS MUSCLE, fig. 349).

Tendon sheaths.—The tendons are held in place by sheaths composed of dense connective tissue. These sheaths vary in different regions. In the simplest form they serve to confine tendons in osseous grooves which they convert into osteo-fibrous canals. Such a sheath is called a **vagina fibrosa tendinis.** It may be strengthened by tendinous bands (**vaginal ligaments**), as on the volar surface of the fingers. In other regions special dense bands or ligaments serve to confine a series of tendons in place, as at the ankle (fig. 365), or fasciæ may be modified for this purpose, as at the back of the wrist (fig. 327).

Synovial bursæ (bursæ mucosæ).—Where there is freedom of action between muscles and tendons and the surrounding parts, there intervenes a loose connective tissue. In regions where the pressure is great or considerable friction would result were these conditions retained, there are developed special cavities with smooth surfaces and containing fluid. Most of these bursæ are developed from the intervening connective tissue at a period in embryonic life preceding muscular activity, but special bursæ may later be developed as the result of unusual pressure or muscular activity after birth. An instance of a bursa lying in a region of friction may be seen in the bursa intervening between the tendinous posterior surface of the ilio-psoas muscle and the ilio-femoral ligament. As an instance of a bursa lying in a region of intermittent pressure may be cited that between the tendon of Achilles and the calcaneus.

Most synovial bursæ intervene between a tendon and a bone, a tendon and a ligament, or between two tendons (**subtendinous bursæ mucosæ**). Others lie between two muscles, a muscle and some skeletal part, or between a muscle and a tendon (**submuscular bursæ mucosæ**); or below a fascia (**subfascial bursæ mucosæ**). Subcutaneous bursæ have been referred to in connection with the tela subcutanea (see p. 315). Most bursæ are developed near joints. The bursæ may so expand during active life that they come to communicate with other bursæ or with a neighbouring joint cavity.

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* The terms fascia and aponeurosis are often loosely and interchangeably used. It seems best to make a distinction by restricting the term fascia to membranous sheets of investment, and aponeurosis to broad tendons. The latter may, however, be inserted into and form a part of the former.

Synovial sheaths (vaginæ mucosæ tendinum).—Synovial sheaths are developed about tendons where the latter are confined in osteo-fibrous canals, as in the fingers. The wall of the canal and the enclosed tendon, or tendons, are each covered by a smooth membrane which at the extremities of the canal is reflected from the wall to the tendon. Between the membrane covering the tendon and that lining the canal is a synovial cavity. An interesting feature of these tendon-sheaths is the presence of **mesotendons,** delicate bands of vascular connective tissue which run in places from the osseous groove to the tendon and carry blood-vessels and nerves.

Nerves.—To each muscle of the body a nerve containing motor and sensory fibres is distributed. A few muscles receive two or more nerves. Sherrington has estimated that in the muscle nerves of the cat two-fifths of the fibres are sensory and three-fifths motor.

The muscles of the head and in part those of the neck are supplied by branches of the cranial nerves. The intrinsic muscles of the neck, back, thorax, and abdomen are supplied by branches which arise fairly directly from the spinal nerves. The muscles of the limbs are supplied by branches from nerve-trunks which arise from plexuses formed by the spinal nerves in the regions near which the limbs are attached.

The main nerve-trunks lie beneath the superficial muscles. They usually run in the intermuscular septa which separate the deeper groups of muscles from one another and from the superficial muscles. The nerve-branches which enter a given muscle usually pass in where the larger intramuscular septa approach the surface of the muscle, and then ramify through the perimysium internum, the smaller branches being distributed in the finer layers of connective tissue which surround and separate the primary muscle fibre-bundles, to the constituent muscle-fibres of which terminal branches are given. The sensory nerve-endings are distributed chiefly in the large intramuscular septa. The tendons are also richly supplied with branches containing sensory fibres.

The size of a nerve supplying a muscle is not proportional to the size of the latter, but rather to the complexity of movements in which the muscle plays a part.

The distribution of the motor nerves varies according to the architecture of the muscle, but in general it appears that the nerves are so distributed as to carry the main branches of distribution most directly to the middle of the constituent fibre-bundles. This is seen most clearly in muscles with comparatively short fibre-bundles, where the individual muscle-fibres run nearly or quite the entire distance from tendon to tendon (fig. 304, a, c, d, e, g, h, and i). When the distance is long, a marked plexiform arrangement is found (fig. 304. b and f).

Vessels.—The muscles are richly supplied with blood. In many instances the larger blood-vessels accompany the larger nerve-trunks as they enter the muscle, and their primary branches are distributed in the larger intramuscular septa. Often, however, the main blood-vessels approach a muscle from a direction different from that taken by the nerves. Veins, as a rule, accompany all but the smallest arteries within the muscle. The veins are richly supplied with valves. Rich capillary plexuses surround the muscle-fibres.

The connective-tissue sheaths, the larger intramuscular septa, and the tendons of muscles are richly supplied with lymphatics. There is doubt concerning the existence of lymphatics within the muscle substance.

Nomenclature.—The names of the various muscles and their classification are less satisfactory than is desirable. The muscular system was first carefully studied in the human body, and names based sometimes upon the shape, structure, size, or position, at other times upon the supposed function or other associated facts, were applied to the muscles found in various regions. Sometimes two or more names were applied to a muscle to indicate several of these factors. Thus *trapezius* and *triangularis* indicate the shape of the corresponding muscles; *biceps* or *triceps* indicates the origin by two or three heads; *rectus*, *obliquus*, and *transversus* represent the direction taken by a muscle or its constituent fibre-bundles; *magnus* and *minimus* indicate size; *sublimis* (superficial) and *profundus* (deep) represent the relative positions occupied; *sterno-cleido-mastoid* indicates structures to which the muscle is attached; *flexor* and *extensor* indicate function; and *sartorius* indicates that the corresponding muscle was supposed to be of use to tailors.

Since a careful study has been devoted to the comparative anatomy of the muscles in various vertebrates, it has become apparent that a simple and more consistent nomenclature applicable to corresponding muscles found in various animals would be of great value. A satisfactory nomenclature of this sort has not, however, as yet been devised and adopted in comparative anatomy, and the established usage of the terms now familiarly applied to the muscles of the human body makes it seem improbable that even if such a system were devised for comparative anatomy it could be brought into extensive use in human anatomy. For many of the muscles in the human body various synonyms have been in use in different countries. The International Congress assembled at Basel in 1895, to simplify the nomenclature of human anatomy, adopted in large part the terms in familiar use in England and America. In the following pages the terms approved by the Congress will be employed, but where they differ materially from those previously in use, the synonym will be given in parentheses.

Classification.—The muscles are usually treated strictly according to the region of the body in which they are found. This method of consideration is still of value in a dissector's guide and in text-books of topographical anatomy. But in studying the muscles scientifically it is of importance also to consider them in their more fundamental genetic relationships to one another and to the nervous system. Embryology and comparative anatomy have proved of the greatest value in revealing these relationships. Studies of this nature have revealed well-marked relationships in the adult human musculature which are of practical as well as scientific importance. The voluntary musculature may be broadly divided into that of the skeletal axis, the limbs, and the visceral orifices. The musculature of each of these divisions has a different and in general simpler form in the lower than in the higher vertebrates, and in the embryos of the higher vertebrates than in the adult. The musculature of the spinal region of the body axis of fishes, the tailed amphibia, and all vertebrate embryos is metamerically segmented; that is, it is divided along the axis of the body into a series of components corresponding with the segmentation of the vertebral column. Although marked alterations take place in the subsequent ontogenetic differentiation in higher vertebrates, traces of this primitive segmentation are still to be found in the adult; in man, for instance, in the intercostal muscles and the segments of the rectus abdominis. In the region of the head conditions are complex, owing to the concurrent presence of muscles which primitively correspond in nature with the segmental spinal musculature, and muscles non-segmental in character, which surround the visceral orifices. This also is true of the anus and external genitalia, where, however, the conditions are simpler. Embryology and comparative anatomy have done much to clear up puzzling features in both regions.

The muscles of the limbs are metamerically arranged in no adult vertebrate. In some of the lower forms a series of axial muscle segments, myotomes, furnishes material from which the musculature of the limbs is differentiated. In the mammals this appears not to be the case, and the muscles are differentiated from the non-segmental tissue of the limb-buds.

Where mammalian musculature is primitively segmental, each segment becomes associated with a corresponding spinal nerve or, in the head, with a nerve which corresponds in series with a spinal nerve. Even when subsequent differentiation brings about marked alterations in the axial musculature, the nerves maintain to a considerable degree a segmental distribution.

Into each of the limbs, where the intrinsic musculature is at no time segmental, there extends during embryonic development a series of segmental spinal nerves, so that in them, as in the region of the body axis, a certain segmentation in the nerve-supply can be made out in the adult. That part of the limb nearest the head in early embryonic development has its muscles supplied by the most cranial, that part nearest the caudal extremity of the body by the most caudal, of the nerves which serve to supply the limb musculature. There is here, however, considerable overlapping of the segmental areas.

Variation.—In man some variation in the arrangement of the muscles is met with in every individual, and often marked deviations from the normal conditions are found. The muscles vary in their mode of origin or insertion, and in the extent to which muscles of a given group are fused with one another or to which the chief parts of a complex muscle are isolated from one another. Some muscles, like the palmaris longus and the plantaris, are frequently entirely absent, and other muscles generally absent are frequently present.

In addition to these frequent variations there are others so rare that many authors prefer to speak of them as anomalies rather than variations. Sometimes muscles may be found doubled by longitudinal division, or two or more muscles normally present may be fused into a single indivisible muscle. Occasionally there occur muscles constantly present in some of the lower animals, but normally not met with in the human body (anomalies of reversion). In such instances the muscle may be normally represented by a tendon or fascia. At times the anomalies are supposed to be not a reversion to an ancestral condition, but a distinct step in advance. This, however, is difficult to prove. At other times no phylogenetic relation is apparent, and the anomaly is looked upon as a monstrous sport or as the result of some pathological condition.

The nerve-supply of the muscles is of value in the study of muscle variations. There is, however, not infrequent variation in the nerves with relation to the supply of the muscles.

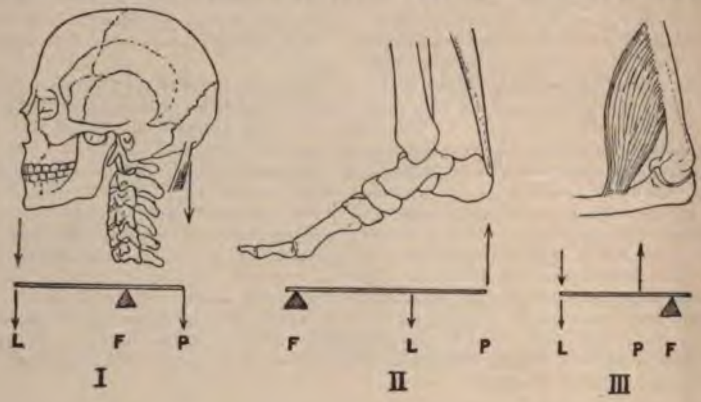
Physiology.—From the standpoint of morphology the muscles are grouped according to their intimate relations to one another and to the peripheral nerves, relations, as noted above, that are made more clear by a study of comparative anatomy and embryology. From the physiological aspect a different grouping of the muscles is required, because muscles belonging morphologically in one group may have different physiological functions in the animal body. The chief features of the mechanical action of muscles may be briefly considered here.

Most muscles act on the bones as levers. In physics three types of levers are recognised. In levers of the first type (fig. 305, I) the fulcrum (F) lies between the place where power (P) is exerted on the lever and the point of resistance or load (L). Levers of this kind are frequently met with in the body. A good example is seen in the attachment of the skull to the vertebral column. The fulcrum lies at the region of attachment; the weight of the skull tends to bend the head forwards, while the force exerted by the dorsal muscles of the neck serves to keep the head upright or to bend it back.

In levers of the second class (fig. 305 II) the point on which power is exerted moves through a greater distance than the point of resistance. Speed of movement is thus sacrificed to power. Levers of this type are exceedingly rare in the animal body. An example in the human body is the foot when the body is raised on the toes.

In levers of the third class (fig. 305, III) the point on which force is exerted moves a less distance than the point of resistance. Power is thus sacrificed to speed. This is the common form of leverage found in the body. A good example is found in the action of the muscles which flex the forearm on the arm. The region in which the biceps and brachialis are attached is but a short distance from the elbow-joint or fulcrum, while the hand may be looked upon as the region of resistance to the force exerted. A movement of the point P through a short distance will cause L to move through a great distance.

Fig. 305.—Three Diagrams (after Testut) to Illustrate Different Types of Levers in their Relations to the Mechanical Action of the Muscles.



The more the angle between a muscle or its tendon and the bone on which it acts approaches a right angle, the greater is the power of movement exerted by the muscle. The arm in fig. 305, III, is in the position of greatest advantage for the action of the biceps on the forearm. All boys know that it is easier to 'chin' oneself after the arm is partly bent than when hanging straight from a bar. Many of the muscles run nearly parallel with the parts on which they act, but the tendons before their attachment are usually either carried over a bony prominence or some fascia or ligament acts as a pulley so that the tendon is inserted at an oblique angle. At other times a process for the attachment of the tendon projects from the bone and causes the force of the contracting muscle to be more advantageously exerted on the bone. It may, of course, readily be seen that the greater the distance of the attachment of a muscle from the joint over which it acts, the greater will be the power exerted by the muscle.

In considering the movements of the body, it is convenient to recognise two groups, simple and complex. To the former, which alone can be considered in a text-book of anatomy, belong such movements as flexion, extension, abduction, adduction, rotation, etc., while to the latter belong those associated movements which give rise to changes in the positions of the body as a whole or of extensive regions of the body.

In **flexion** the extremities of the trunk or limbs or special portions of those regions are bent near to one another; in **extension** the reverse movement is brought about. The parts are straightened or even bent beyond the straight position (over-extension).

In **abduction** transverse movements are made, a part being bent away from the median line of the body or limb; in **adduction** the reverse movement is brought about.

In **rotation** a part is turned on its longitudinal axis. The rotation of the femur at the hip-joint is called internal rotation when the toes are turned inwards, external rotation when the toes are turned outwards. Rotation at the shoulder-joint is called internal when the thumb is turned forwards and inwards towards the body, external when the reverse movement takes place. These movements are also carried out at the elbow-joint, but here internal rotation is called **pronation**, external rotation, **supination.**

At the shoulder-joint the raising of the arm towards the back is called extension; towards the front, flexion; and towards the side, abduction. Moving the arm against the body is called adduction.

The contraction of a given muscle seldom gives rise to a simple movement of the nature of those just mentioned. Even when the muscle acts on only one joint, the result of its action is apt to be complex. When a muscle passes over and acts on a series of joints, it may cause flexion at one joint, extension at another. Thus the gastrocnemius muscle causes flexion at the knee, extension at the ankle. In the body the muscles act in groups, so that the action of each individual muscle is even more complex than might be judged merely from anatomical study.

Muscles which produce a movement in a common direction are called **synergists,** while those whose contraction produces opposite movements are called **antagonists;** e. g., the flexors and extensors are antagonists. In the actual working of the muscular system, however, when a set of muscles is contracting to produce a movement, the antagonists also contract to a certain degree. The movement is the result of nerve impulses sent simultaneously to all the muscles which act on the part moved.

The relation of the internal architecture of a muscle to the movements to which its contraction gives rise is a complex subject, the details of which cannot be entered into here. In general it may be said that when the fibre-bundles run directly from one attachment to the other, as in fig. 304, a and f, the force exerted by the contraction of the individual muscle-fibres is most efficiently utilised and the extent of the movement varies directly as the length of the fibres, while the force exerted varies directly with the number of the fibres.

In muscles of the types indicated in fig 304, g, h, i, a certain amount of the extent of movement and of the force exerted by the contraction of the individual fibres is not effectively exerted on the parts moved by the muscles, as may be seen by applying to this action the laws of the parallelogram of forces. In such muscles, however, the great number of short muscle-fibres composing them makes possible the exertion of great power with some loss of speed of contraction in the muscle as a whole.

The direction of the movements which result from muscular contraction is in large part determined by the shape of the articular surfaces, none of which are to be looked upon as simple fulcra, but instead, during a given movement, the fulcrum shifts from one region to another of the joint.

Order of treatment.—The muscles and fasciæ are here treated in the following order:—(1) those of the head and neck (p. 324); (2) those of the arm (p. 355); (3) those of the back (p. 401); (4) those of the thorax and abdomen (p. 412); (5) those of the leg (p. 426). The reason for taking up the musculature in the order named is, that during embryonic development musculature belonging primitively to the head comes to overlap that of the neck; that of the neck spreads over the region of the back and thorax, and becomes attached to the shoulder-girdle; that of the arm extends over the region of the thorax, abdomen, and back; that of the back partially over the region of the thorax; while that of the abdomen enters into intimate relation with the pelvic girdle. So far as practicable the musculature of these various regions will be taken up according to fundamental morphological relationships.

Since a morphological grouping of the muscles does not accord perfectly with a physiological grouping, there is given at the end of this section a table showing what muscles are concerned in performing the simpler voluntary movements.

The topographical relations of the muscles in various regions of the body are illustrated in the series of cross-sections given for each region.

Tables illustrating the relations of the central nervous system and the peripheral nerves to the muscles are given in the section on the nervous system (Section VI).

I. MUSCULATURE OF THE HEAD AND NECK AND THE AXIO-CINGULAR MUSCULATURE

GENERAL RELATIONS

In front the hyoid bone, on the side a line drawn from the hyoid bone to the mastoid process of the temporal bone, and behind the superior nuchal line and external protuberance of the occipital bone, indicate the division of the head from the neck. The neck extends from here to the cranial margin of the thorax.

A. The **musculature of the head**, with the possible exception of the small genio-hyoid, is supplied by cranial nerves. It falls into several well-defined groups:—(1) **Facialis group.** A set of muscles connected with the scalp and the skin of the face and neck and the mucous membrane of the lips and cheek. All these muscles are supplied by the seventh cranial nerve. (2) **Intraorbital.** Muscles within the orbit which serve to move the eyeball and elevate the eyelid. Innervated by third, fourth, and sixth cranial nerves. (3) **Cranio-mandibular.** Muscles of mastication passing from the cranium to the lower jaw. Supplied by the fifth cranial nerve. (4) **Muscles of the middle ear.** Supplied by the fifth and seventh cranial nerves. (5) **Muscles of the soft palate and pharynx.** Innervated by fifth, seventh, ninth, and tenth cranial nerves. (6) **Muscles of the tongue.** Innervated by the twelfth cranial nerve. (7) **Suprahyoid.** Passing from the hyoid bone to the base of the cranium and to the mandible. Innervated by the fifth and seventh cranial nerves.

B. The **musculature of the neck** is supplied in part by cranial, in part by spinal, nerves. It may be conveniently subdivided as follows:—

(1) **Subcutaneous.** A muscle, the platysma, extends subcutaneously over the ventrolateral surface of the neck into the thoracic region and the region of the shoulder. This muscle is innervated by the seventh cranial nerve and belongs essentially with the facialis group of the muscles of the head, with which it will be treated. (2) **Superficial axio-cingular.** From the back of the base of the skull two muscles, the sterno-cleido-mastoid and the trapezius, extend to the shoulder girdle. The trapezius muscle also takes origin from the spines of the cervical and thoracic vertebræ. These muscles are innervated in part by the eleventh cranial and in part by cervical nerves. The fibres of the former nerve, the spinal accessory, are, however, derived from the cervical region of the spinal cord. (3) **Infrahyoid.** The muscles of this group, more deeply placed than the last mentioned, extend between the hyoid bone and the thyreoid cartilage, and from these structures to the sternum and the scapula. They are innervated by the first three cervical nerves through the ansa hypoglossi. (4) **Laryngeal.** Supplied by branches of the tenth cranial nerve. The nerve-fibres are possibly derived through anastomosing branches from the eleventh cranial nerve. (5) **Pharyngeal.** Continuous with the pharyngeal muscles of the head. Supplied by branches of the tenth cranial nerve. The nerve-fibres may be derived from the eleventh. (6) **Scalene.** Muscles which extend at the side of the neck from the transverse processes of the cervical vertebræ to the first two ribs. These are supplied by direct branches from the anterior divisions of the cervical nerves. (7) **Prevertebral.** Muscles which extend along the ventro-lateral surface of the bodies of the upper thoracic and the cervical vertebræ to the base of the skull. They are supplied by direct branches from the anterior divisions of the cervical nerves. (8) **Anterior intertransverse muscles.** These belong to the ventral neck musculature, and are innervated by branches from the anterior divisions of the spinal nerves. (9) **Deep dorsal musculature of the neck.** This is supplied by the posterior divisions of the spinal nerves and forms an essential part of the general system of dorsal musculature extending from the sacrum to the head.

C. The **deep axio-cingular musculature** consists of muscles which are first differentiated in the lateral cervical region of the embryo, and which later become united to the scapula. In large part this musculature wanders distally over the back and thorax during the course of embryonic development, but its cervical origin is indicated by an innervation through direct branches from the anterior divisions of the cervical nerves. It consists of the *rhomboid muscles*, which extend from the vertebral margin of the scapula to the spines of the lower cervical and upper thoracic vertebræ, of the *levator scapulæ*, which extends between the scalene muscles and the cervical division of the intrinsic dorsal musculature from the first four cervical transverse processes to the medial angle of the scapula, and of the *serratus anterior* (*magnus*), which arises from the antero-lateral region of the thoracic wall and, closely applied to this, extends dorsally to the vertebral margin of the scapula.

Of the various groups of muscles mentioned above, some, for the sake of convenience. are treated in connection with the organs to which they belong. Thus the muscles of the eye are taken up in Section VII; those of the ear in Section VII; of the palate in Section VIII; pharynx in Section VIII; and larynx in Section VIII. The deep dorsal musculature of the neck will be taken up in the section on the intrinsic muscles of the back, p. 401. The remaining groups of muscles will be taken up in the following order:—

(1) The facialis group, p. 325.
(2) The cranio-mandibular group, p. 333.
(3) The superficial axio-cingular group, p. 337.
(4) The suprahyoid group, p. 340.
(5) The muscles of the tongue, p. 343.
(6) The infrahyoid group, p. 345.

(7) The scalene group, p. 348.
(8) The prevertebral group, p. 350.
(9) The anterior cervical intertransverse, p. 351.
(10) The deep axio-cingular musculature, p. 351.*

The **fasciæ of the head and neck** are taken up in connection with the groups of muscles with which they are most intimately associated. The tela subcutanea is treated in the section on the facialis group of muscles (p. 325); and the temporal, masseteric, and pterygoid fasciæ in connection with the cranio-mandibular muscles (p. 334). The external layer of cervical fascia, which completely surrounds the neck and ensheaths the superficial axio-cingular muscles, is taken up in connection with these muscles (p. 337). The middle layer, which ensheaths the infrahyoid muscles, the deep layer, which encloses the scalene and prevertebral muscles, and the fascial complex, ensheathing the deep axio-cingular muscles, are each taken up in connection with the corresponding muscle-groups. The fasciæ investing the intrinsic dorsal muscles of the neck are considered in the section on the dorsal musculature (p. 401). In addition to the fasciæ mentioned, sheaths invest the pharynx, larynx, and the carotid artery, internal jugular vein, and vagus nerve.

1. THE FACIALIS MUSCULATURE

(Figs. 306–308)

The muscles of this group are intimately connected with the scalp, with the skin of the face and neck, and with the mucous membrane lining the lips and the cheeks. In the main the musculature is arranged radially about the chief orifices, the aural, orbital, nasal, and oral. In addition there are circular sphincter muscles about the orbit and the mouth. Most of the muscles have an osseous origin and a cutaneous insertion, but there are exceptions. Both origin and insertion may be cutaneous, or the attachment may be to an aponeurosis instead of directly to the skin. The deeper musculature about the mouth is attached to the mucous membrane.

The muscles are composed of interdigitating muscle-fibres which are grouped in bundles that take a nearly parallel or slightly converging course and give rise to thin muscle-sheets.

The region from which the facial musculature originates in the embryo is, in the main at least, that of the hyoid arch immediately below the ear. From here the musculature spreads with the development of the facial nerve, dorsally to the occipital region behind the ear, distally over the neck, ventrally over the face, and upwards towards the eye, forehead, and the side of the skull. The course of the development is indicated by the branches of the facial nerve. A somewhat similar phylogenetic development is indicated by conditions found in the inferior mammals and lower vertebrates. According to Ruge and Gegenbaur, the facial musculature is to be looked upon as derived from two muscle-sheets, of which in man the deeper has disappeared in the region of the neck while it is differentiated into the deeper facial muscles in the region of the head. The deeper layer of transverse fibres in the neck, the *sphincter colli*, is found in several of the mammals. The complex development of the facial muscles in man is characteristic of the human species, and is associated with the use of these muscles as a means of expression of the emotions, a physiological function superadded to the primitive function of opening and closing visceral orifices. There is much individual variation in the differentiation of the muscles.

Fasciæ.—The skin of the head and neck is, in most regions, firmly fused with the **tela subcutanea.** This is composed of a dense fibrous tissue united by a looser areolar tissue to the underlying structures. But a slight amount of fat is embedded in the subcutaneous tissue of the scalp, forehead, and nose. Considerable fat may be embedded in the region of the cheeks, the back of the neck, and the under surface of the chin (double chin).

The subcutaneous muscles of the cranial vault and the neck are invested with fascial membranes. That covering the cranial musculature externally is firmly fused to the subcutaneous tissue of the scalp. That covering the subcutaneous muscle of the neck is less firmly fused with the subcutaneous tissue. In the facial region the more superficial muscles are so closely embedded in the subcutaneous tissue that no distinct fasciæ intervening between the muscles and the skin can, as a rule, be distinguished. Of the deeper muscles of the facialis group, the buccinator alone possesses a distinct fascia. This muscle lies upon the mucous membrane of the lateral wall of the mouth, and is covered externally by a fascia continued into the fascia investing the superior constrictor of the pharynx

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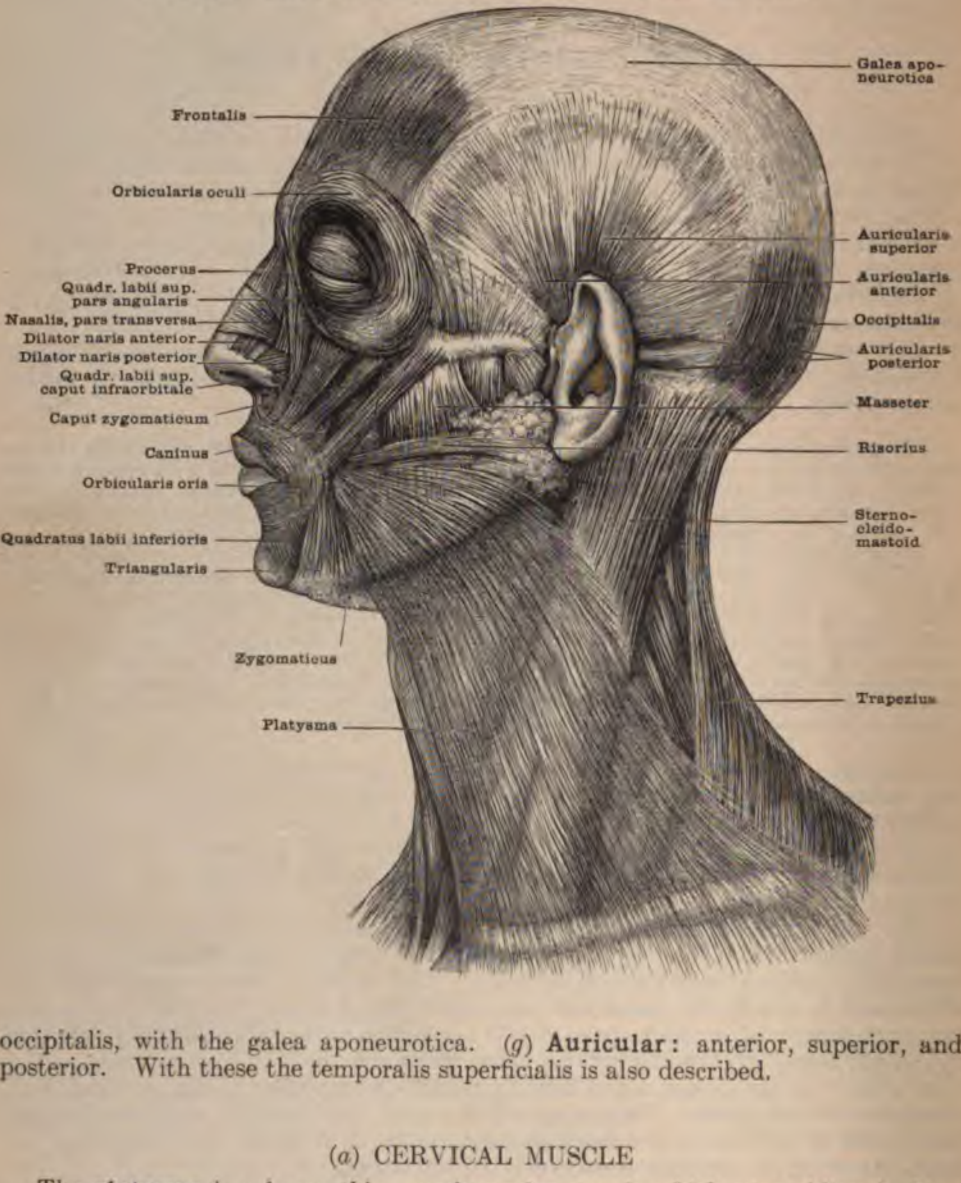
* The pectoral muscles and the latissimus dorsi, which extend from the skeleton of the limb to the front and side of the thorax and the lower part of the back, arise from the limb bud during embryonic development, are innervated through the brachial plexus, and will, therefore, be taken up in considering the intrinsic musculature of the arm, pp. 361 and 365.

Bursæ.—**Bursa subcutanea prementalis.** Between the periosteum at the tip of the chin and the overlying tissue. **Bursa subcutanea prominentiæ laryngeæ.** In front of the junction of the right and left laminæ of the thyreoid cartilage.

Muscles.—The muscles of the facialis group may be conveniently subdivided as follows:—

(*a*) **Cervical**: the platysma. (*b*) **Oral**: the orbicularis oris and the incisivus labii superioris and inferioris; the quadratus labii superioris and inferioris; the caninus, zygomaticus, risorius, and triangularis; and the buccinator. (*c*) **Mental.** (*d*) **Nasal**: the nasalis, depressor septi, and the dilatores naris. (*e*) **Periorbital**: the orbicularis oculi, corrugator, and procerus. (*f*) **Epicranial**: the frontalis and occipitalis, with the galea aponeurotica. (*g*) **Auricular**: anterior, superior, and posterior. With these the temporalis superficialis is also described.

FIG. 306.—THE SUPERFICIAL MUSCLES OF THE HEAD AND NECK.


Galea aponeurotica
Frontalis
Orbicularis oculi
Auricularis superior
Procerus
Quadr. labii sup. pars angularis
Auricularis anterior
Nasalis, pars transversa
Occipitalis
Dilator naris anterior
Dilator naris posterior
Auricularis posterior
Quadr. labii sup. caput infraorbitale
Masseter
Caput zygomaticum
Risorius
Caninus
Orbicularis oris
Sterno-cleido-mastoid
Quadratus labii inferioris
Triangularis
Zygomaticus
Trapezius
Platysma

(*a*) CERVICAL MUSCLE

The **platysma** is a large, thin, quadrangular muscle which runs obliquely from the chin, the corner of the mouth, and the lower part of the cheek across the mandible and the neck to the proximal part of the thorax and shoulder. The muscles of each side interdigitate across the chin. A short distance below the chin, in the neck, the ventral margins diverge (fig. 306).

Origin.—From the tela subcutanea by somewhat scattered bundles—(1) along a line extending from the cartilage of the second rib to the acromion, and (2) along the dorsal margin of the muscle.

Insertion.—Into—(1) the mental protuberance of the mandible and the inferior margin of the mandible; and (2) into the skin of the lower part of the cheek and at the corner of the mouth, where it fuses more or less with the quadratus labii inferioris and the orbicularis oris.

Nerve-supply.—The cervical branch (ramus colli) of the seventh cranial nerve forms beneath the muscle a plexus to which the cutaneus colli nerve contributes sensory branches.

Relations.—The muscle is situated beneath the panniculus adiposus, to which in the neck it is not very firmly attached. For the most part it is separated from the external layer of the cervical fascia by loose areolar tissue. The main cutaneous rami of the cervical plexus and the external jugular vein lie beneath the muscle.

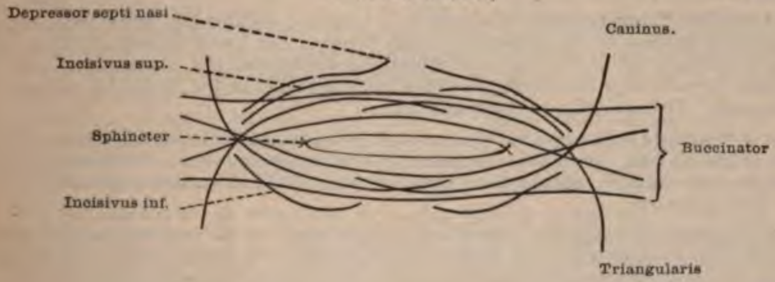
Action.—It wrinkles up the skin of the neck, depresses the corner of the mouth, and thus plays a part in expression of sadness, fright, and suffering. It aids the circulation by relieving pressure on the underlying veins.

Variations.—Either the facial or the distal development of the muscle may be more extensive than that described above. On the other hand, it may be less developed than usual, and rarely it is absent. Accessory slips have been seen going to the zygoma, the auricle, or the mastoid process, etc., and to the clavicle and sternum. Rarely a deep transverse layer is found in man.

(*b*) ORAL MUSCLES

The muscles of the mouth belonging to the facialis system include several intralabial muscles:—a sphincter, the **orbicularis oris;** a transverse, the **compressor labii;** and four deep submucous muscles which pass from the corners of the lips towards the alveolar juga of the upper canine and lower lateral incisor teeth, the **incisivi labii superioris** and **inferioris.** From each corner of the mouth there radiate out several muscles: the **caninus** and **zygomaticus** upwards to the maxilla and zygomatic bone; the **risorius** lateralwards over the cheek; the **platysma** and the **triangularis** downwards over the side of the jaw; and the **buccinator,** lateralwards over the side of the oral cavity. From each of these fibre-bundles are continued into the more peripheral and superficial portions of the orbicularis. In addition to these muscles there are two retractors or quadrate muscles, one of which, the **quadratus labii superioris,** extends from the upper lip medial to the angle towards the bridge of the nose, the orbit, and the zygomatic bone; while the other, the **quadratus labii inferioris,** extends from a corresponding position in the lower lip towards the side of the chin. The orbicularis oris, compressor labii, and incisive muscles serve to close the mouth; the other muscles to open it and to pull the lips in various directions. The buccinator, however, plays a part in the closing of the mouth by offering support for the orbicularis.

FIG. 307.—DIAGRAM TO ILLUSTRATE THE ARCHITECTURE OF THE ORBICULARIS ORIS. (After T. D. Thane.)



INTRALABIAL MUSCLES

The **orbicularis oris** (figs. 306, 307, 308) is a complex muscle which surrounds the oral orifice and forms the chief intrinsic musculature of the lips. Immediately about the orifice, and on the deep surface of the muscle, is a fairly well-defined sphincter, although at the corners of the mouth the fibre-bundles of one lip cross those of the other and are inserted into the skin and mucosa. About this sphincter area and between its outer margin and the skin is a complex musculature comprised chiefly of fibres prolonged from the muscles which radiate from the corners of the mouth. The more superficial portion of the muscle in the upper lip is composed mainly of fibre-bundles from the triangularis (depressor anguli oris), the more superficial portion of that in the lower lip by fibre-bundles from the caninus (levator anguli oris). These fibre-bundles form commissures at the angles of the mouth and extend towards the median line, where many of them interdigitate with those of the opposite side. They are attached to the skin of the lips. The deeper portions are largely formed by fibre-bundles prolonged from the buccinator, the mandibular fibre-bundles of the latter muscle going mainly to the upper lip, the maxillary fibre-bundles mainly to the lower lip (see p. 329). These fibre-bundles are attached chiefly to the mucosa, but some extend outwards to the skin of the lips.

The **compressor labii,** or muscle of Klein, is composed of bundles of fibres which take a course transverse to those of the orbicularis, and pass obliquely from the skin surrounding the oral orifice towards the mucosa which bounds its inner margin. It is said to be best marked in infants.

The **incisivus labii superioris** is a small muscle-bundle which passes from the alveolar jugum of the upper canine tooth to the back of the orbicularis near the corner of the mouth.

The **incisivus labii inferioris** passes similarly from the alveolar jugum of the lower lateral incisor tooth to the back of the orbicularis in the lower lip.

Nerve-supply.—These muscles are supplied by the buccal branches of the facial nerve which enter the orbicularis on the lateral border.

Relations.—The main mass of intrinsic musculature of the lips is placed slightly nearer the mucosa than the skin. On its deep surface lie the labial arteries.

Action.—The orbicularis draws the upper lip downwards, the lower lip upwards. The incisive muscles draw the corners of the lips inwards, and the compressor flattens the lips. Together they serve to close the mouth. Acting separately they may draw different parts of it in the directions indicated by their structure. The circumferential portion of the orbicularis acting with the incisive muscles makes the lips protrude. The central portion of the orbicularis draws the lips together, and when the buccinator also acts, draws them against the teeth. It is this portion of the muscle that has chiefly to do with nutritive functions. The more peripheral parts of the muscle are chiefly utilised in the expression of the emotions.

RETRACTORS OF THE LIPS OR QUADRATE MUSCLES
(Fig. 306)

The **quadratus labii superioris** is a thin, quadrangular muscle with three heads, all of which are inserted into the skin and musculature of the upper lip.

The **caput zygomaticum** (zygomaticus minor) is long and slender and arises from the lower part of the external surface of the zygomatic bone beneath the lower border of the palpebral portion of the orbicularis oculi. It passes obliquely forwards over the caninus and orbicularis oris muscles, and extends to a cutaneous and muscular insertion in the upper lip medial to the corner of the mouth. It lies medial to the zygomaticus.

The **caput infraorbitale** (levator labii superioris), a broad, flat muscle, arises from the infraorbital margin of the maxilla, where it is concealed by the orbicularis oculi. It extends obliquely forwards over the caninus and beneath the caput angulare to the skin and musculature of the lateral half of the upper lip.

The **caput angulare** (levator labii superioris alæque nasi) arises from the root of the nose, where it is fused with the frontalis. As it descends it divides into two fasciculi, one of which is attached to the skin and the alar cartilage of the nose; the other passes obliquely backwards over the caput infraorbitale to the skin and musculature of the lateral half of the upper lip.

Nerve-supply.—The zygomatic ramus of the seventh nerve sends branches to enter the deep surface of each of the divisions of the muscle.

Actions.—It raises the lateral half of the upper lip and the wing of the nose. It is of value in inspiration, serves to express the emotion of discontent, and comes into play in violent weeping.

Variations.—The caput zygomaticum is often absent. It may be fused with the zygomaticus (major). It may be doubled. Its origin may extend to neighbouring structures. The other heads, though more stable, vary considerably, especially in the extent of their fusion with neighbouring muscles.

The **quadratus labii inferioris** (depressor labii inferioris) is a thin, rhomboid muscle which arises below the canine and bicuspid teeth from the base of the mandible, between the mental protuberance and the mental foramen, and extends obliquely upwards in a medial direction to the orbicularis oris, through which its fibre-bundles pass. Its more medial fibres cross at their insertion with those of the muscle of the other side. It is attached to the skin and mucosa of the lower lip. It is essentially a part of the platysma, and is superficially united to the skin except where covered by the triangularis (depressor anguli oris). It crosses the mental vessels and nerves and a part of the mentalis (levator menti).

Nerve-supply.—The mandibular branch of the facial sends twigs into its deep surface near the lateral border.

Action.—It draws down and everts the lower lip. It is an antagonist of the mentalis (levator menti). It plays a part in the expression of terror, irony, great anger, and similar emotions.

MUSCLES OF THE ANGLE OF THE MOUTH
(Figs. 306, 307, 308, 309)

The **caninus** (levator anguli oris) is a flat, quadrilateral muscle which arises from the canine fossa of the maxilla and runs beneath the quadratus (levator) labii superioris to the corner of the mouth, where it becomes attached to the skin and sends some fasciculi into the orbicularis of the lower lip. Between the caninus and the quadratus labii superioris there is a certain amount of fatty areolar tissue through which the infraorbital vessels and nerves run. Its deep surface extends over the canine fossa, the buccinator muscle, and the mucosa of the lip. The external maxillary (facial) artery passes over its inferior extremity.

The **zygomaticus** (z. major) is a long, ribbon-shaped muscle which arises by short tendinous processes from the zygomatic bone near the temporal suture under cover of the orbicularis oculi. It passes obliquely to the corner of the mouth, where it is attached to the skin and mucosa. The body of the muscle is subcutaneous and is usually surrounded by fat. It crosses the masseter and buccinator muscles and the anterior facial vein.

The **risorius** is a thin, triangular, subcutaneous muscle which extends across the middle of the cheek and lies in a more superficial plane than the platysma, with which it is often fused. It arises from the tela subcutanea above the parotid fascia. Its fibres converge across the masseter muscle towards the angle of the mouth and are attached to the skin and mucosa in this vicinity.

The **platysma** has been described above.

The **triangularis** (depressor anguli oris) is a broad, flat, well-developed, subcutaneous muscle which arises from the base and external surface of the body of the mandible below the canine, bicuspid, and first molar teeth. From here its fibres converge towards the corner of the mouth, where they are in part inserted into the skin and part are continued into the orbicularis oris of the upper lip. It overlies the buccinator and the quadratus (depressor) labii inferioris muscles. Not infrequently (56 out of 92 bodies—LeDouble) some fasciculi are continued into the neck as the **transversus menti,** a fibro-muscular band formed by the interdigitation of the slips prolonged from each side below the chin and superficial to the platysma.

Nerve-supply.—The zygomatic branch of the seventh nerve supplies the canine (levator anguli oris) and zygomatic (major) muscles. Branches enter the middle of the deep surface of the latter muscle and the superficial surface of the former near its lateral border. The risorius is supplied by branches from the buccal rami of the seventh nerve, which enter its deep surface. The triangularis (depressor anguli oris) is supplied by the buccal nerve through branches which enter its deep surface near the posterior margin.

Action.—The caninus (levator anguli oris) and zygomatic (z. major) muscles raise the corner of the mouth, the former at the same time drawing it medially, the latter, laterally. The caninus gives rise to expression of bitterness or menace. The zygomaticus is active in smiling or laughing. When contracted greatly it serves to elevate the cheek and the lower eyelid and produce 'crow's-foot' wrinkles at the corner of the eye. The risorius draws the angle of the mouth laterally. In spite of its name it is not used to express pleasure, but instead gives rise to an expression of pain. The triangularis (depressor anguli oris) depresses the corner of the mouth and draws it laterally, giving rise to the expression of grief.

Variations.—The risorius is very inconstant in its development, and in its relations to neighbouring muscles, and is not infrequently quite small. The zygomaticus is rarely absent. Its origin may extend to the temporal or masseteric fasciæ. It may be doubled throughout its length or at one extremity. Frequently the triangularis is divided into three fasciculi.

The **buccinator** arises from—(1) the molar portion of the alveolar process of the maxilla; (2) the buccinator crest of the mandible, and (3) the pterygo-mandibular raphe of the bucco-pharyngeal fascia. This narrow fibrous band, which separates the buccinator from the superior constrictor of the pharynx, extends from the pterygoid hamulus to the buccinator crest of the mandible. The fibre-bundles are divisible into four sets. The most cranial extend directly into the orbicularis of the upper lip. The next pass through the commissure at the corner of the lips into the orbicularis of the lower lip; the third through the commissure into the orbicularis of the upper lip, and the fourth directly into the orbicularis of the lower lip. The muscle is attached chiefly to the mucosa of the lips near the angle of the mouth. Some fibre-bundles extend to the more medial portion of the mucosa and some through the orbicularis to the skin.

Nerve-supply.—By the buccal branch of the facial nerve through filaments which enter the posterior half of its outer surface.

Relations.—The muscle is covered externally by the thin bucco-pharyngeal fascia; internally by the mucosa of the mouth. Above its outer surface lie the zygomatic (z. major), risorius, and masseter muscles. Between the last and the buccinator lies a large pad of fat (the buccal fat pad). The parotid duct passes forwards over the muscle, and slightly in front of its centre pierces it and passes into the mouth. It is crossed by the external maxillary (facial) artery and anterior facial vein and by the buccal artery and nerve.

Actions.—It draws the corner of the mouth laterally, pulls the lips against the teeth, and flattens the cheek. It is of use in mastication, swallowing, whistling, and blowing wind-instruments.

Variations.—Occasionally it consists of two laminæ, a condition found in many mammals. It may be continuous in part with the superior constrictor of the pharynx, as in the cat.

(*c*) MENTAL MUSCLE

The **mentalis** (levator menti) is a short, thick muscle which arises from the alveolar jugum of the lower medial incisor tooth under cover of the quadratus (depressor) labii inferioris and beneath the oral mucosa, where this is reflected from the lips to the gums. It extends to the chin, where it is fused with the muscle of the opposite side and is attached to the skin of the chin.

Nerve-supply.—The mandibular branch of the seventh nerve sends terminal twigs into this muscle.

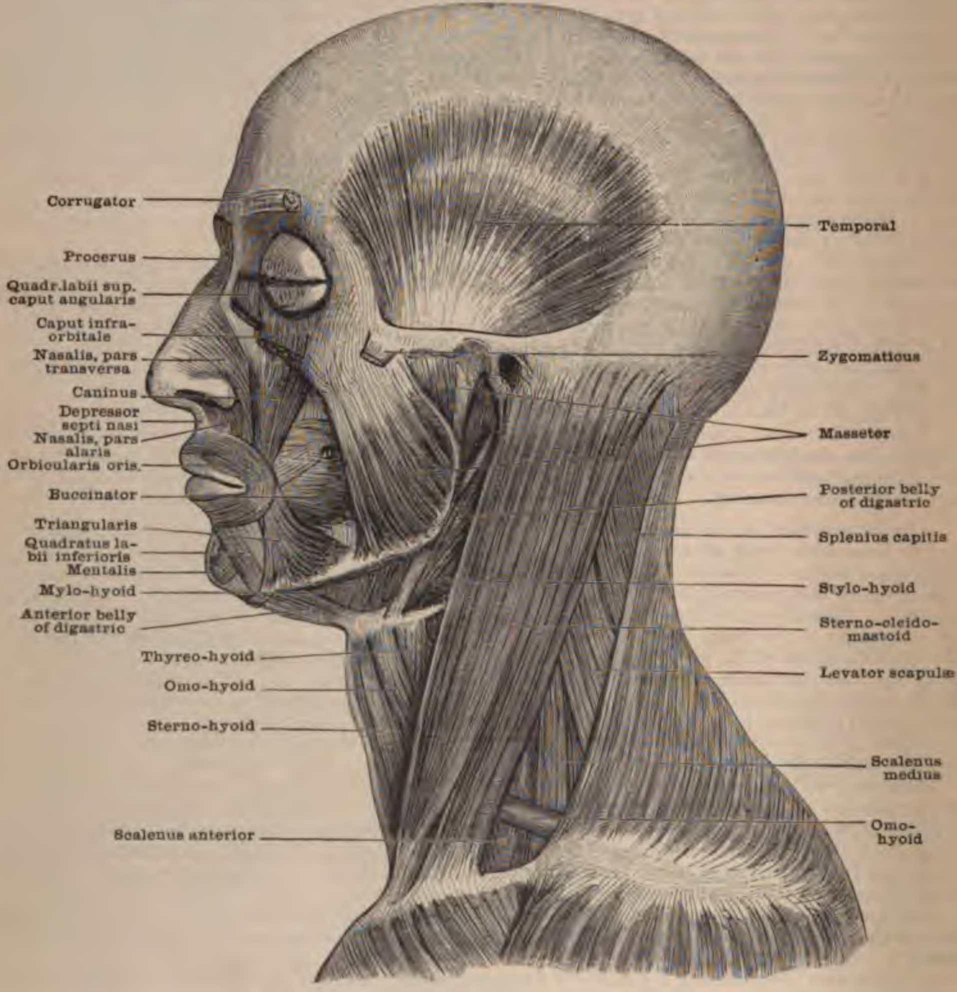
Actions.—It serves to draw up the skin of the chin and thus indirectly to cause the lower lip to protrude. It is of use in articulation, in forcing bits of food from between the gums, and in the expression of various emotions (muscle of pride).

Variations.—It varies greatly in size and generally is fused with the platysma.

(*d*) NASAL MUSCLES
(Figs. 306 and 308)

Towards the nasal apertures several muscles converge. Those extending from above serve to elevate and dilate, those from below to depress and contract, the nostrils. To the former belongs the **pars transversa** of the **nasalis** (compressor naris), a triangular muscle extending from the bridge of the nose to the naso-labial sulcus; the **caput angulare** of the **quadratus labii superioris** (levator labii superioris alæque nasi), which arises from the root of the nose and sends a fasciculus to the wing of the nose; and the **dilatores naris,** described below: to the latter, the **pars alaris** of the **nasalis** (depressor alæ nasi), which extends from the alveolar juga of the upper lateral incisor and canine teeth to the dorsal margin of the nostril; and the small **depressor septi nasi.**

Fig. 308.—The Deeper Muscles of the Face and Neck.


Corrugator
Procerus
Quadr.labii sup. caput angularis
Caput infra-orbitale
Nasalis, pars transversa
Caninus
Depressor septi nasi
Nasalis, pars alaris
Orbicularis oris
Buccinator
Triangularis
Quadratus labii inferioris
Mentalis
Mylo-hyoid
Anterior belly of digastric
Thyreo-hyoid
Omo-hyoid
Sterno-hyoid
Scalenus anterior
Temporal
Zygomaticus
Masseter
Posterior belly of digastric
Splenius capitis
Stylo-hyoid
Sterno-cleido-mastoid
Levator scapulæ
Scalenus medius
Omo-hyoid

The **nasalis** consists of two parts, the pars transversa and the pars alaris. The *pars transversa* (compressor naris) is triangular. It lies on the side of the nose above the wing. Its fibre-bundles arise from an aponeurosis which overlies the bridge of the nose, is adherent to the skin, and is not closely attached to the underlying cartilage. From this aponeurosis the fibre-bundles converge towards the back of the wing, where they are attached to the skin along the line which separates the wing from the cheek (naso-labial sulcus). Its insertion is covered by the nasal process of the caput angulare (levator labii superioris alæque nasi) of the quadratus labii superioris (p. 328), with which its fibres interdigitate. The insertion is also described by many as taking place into the lower part of the canine fossa of the maxilla.

The **pars alaris** (depressor alæ nasi) is a small quadrangular muscle situated below the aperture of the nose, between this and the alveolar portion of the maxilla. It is covered by the mucosa of the gum, by the orbicularis oris and the quadratus (levator) labii superioris, and laterally is fused with the pars transversa (compressor naris). It arises from the alveolar juga of the lateral incisor and the canine teeth. Its fibre-bundles extend vertically to the skin of the dorsal margin of the nostril, from the dorsal part of the cartilage of the wing to the septum.

The **depressor septi** is a flat, triangular muscle which extends from the superficial layer of the orbicularis oris to the lower edge of the nasal septum. It may arise from the jugum alveolare of the medial incisor.

The **dilator naris posterior** is a thin, triangular muscle which lies on the side of the wing of the nose. It arises from the skin of the naso-labial groove and is attached to the inferior border of the wing of the nose.

The **dilator naris anterior** is a very small, thin muscle which runs from the lower margin of the cartilage at the front of the wing of the nose to the skin. It is usually not clearly marked.

Nerve-supply.—The muscles of this group are supplied by the buccal branches of the facial nerve.

Actions.—The transverse portion of the nasalis (compressor naris) acts with the angular head (levator labii superioris alæque nasi) of the quadratus labii superioris in drawing outwards and up the lateral margin of the wings of the nose, and gives rise to the expression of sensuality. (Poirier.) This accords with the electrical experiments of Duchenne. Some investigators consider that the muscle serves to depress the bridge of the nose. The alar portion (depressor alæ nasi) of the nasalis and the depressor septi nasi draw down the nostril. The former tends to contract it from side to side, the latter from front to back, and at the same time to depress the tip of the nose. They play a part in the expression of anger and of pain. The functions of the other muscles are indicated by their names.

Variations.—The muscles of the nose vary considerably in extent of development, and one or more may be absent. Authors differ considerably in their description of several of the muscles. The **anomalus** is a longitudinal muscle strip occasionally found running from the frontal process to the body of the maxilla near the lateral margin of the nasal aperture.

(*e*) PERIORBITAL MUSCLES

(Figs. 306, 308)

The muscles which encircle the orbit serve to constrict the entrance of the orbit so as to shut out light and protect the eye against foreign bodies. To these belong the orbicularis oculi, the corrugator, and the procerus. The **orbicularis oculi** is a large, flat, elliptical muscle which lies in the eyelids and over the bone surrounding the orbit. **Three parts** are recognised, a **palpebral** and an **orbital** and a **lachrymal.** The quadrangular **corrugator** extends from the nasal portion of the frontal bone to the skin of the middle half of the eyebrow; the narrow **procerus** (pyramidalis nasi) from the bridge of the nose to the skin at the root. The muscles which have an antagonistic action are the levator palpebræ superioris and the epicranius. The levator palpebræ is described in the chapter on the EYE (see Section VII), the epicranius in the following subsection.

The **orbicularis oculi.**—The **palpebral portion** arises from the ventral surface and margins of the lateral portion of the medial palpebral ligament (tendo oculi), and from the covering of the lachrymal sac. The fibre-bundles spread out as they pass into the eyelids and again are concentrated towards their insertion into the outer surface of the lateral palpebral ligament. Many of the fibre-bundles interdigitate here without being inserted into the ligament. The muscle in each eyelid lies between the tarsal cartilage and the skin, separated from both by loose tissue. The muscle-fibres nearest the margin of the lids constitute the ciliary muscle, or muscle of Riolan. They are very small fibres and probably act on the eyelashes and Meibomian glands.

The **orbital portion** is inserted medially by a superior insertion into the medial palpebral ligament (tendo oculi), the nasal portion of the frontal bone, the anterior lachrymal crest of the maxilla, and the rim of the orbit as far as the supra-orbital notch; and by an inferior insertion into the medial palpebral ligament and the medial portion of the inferior rim of the orbit. The fibre-bundles form a flat ring which surrounds the orbit for a considerable distance, especially inferiorly. The muscle is adherent to the overlying skin. It lies over the bones surrounding the margin of the orbit and over the attachments of several of the facial muscles attached to these bones. With these muscles some of the fibre-bundles are usually continuous.

The **lachrymal portion** (tensor tarsi or Horner's muscle) arises from the posterior lachrymal crest of the lachrymal bone and passes down on the dorsal surface of the lachrymal sac and the medial palpebral ligament (tendo oculi). It bifurcates and furnishes a fasciculus attached to each tarsal cartilage. Some of the fibre-bundles surround the lachrymal canaliculi.

The **corrugator** arises from the frontal bone near the fronto-nasal suture. It extends obliquely upwards to be inserted into the skin of the middle half of the eyebrow. The fibre-bundles of insertion interdigitate with those of the frontalis. The muscle lies relatively deep. It is covered by the procerus (pyramidalis nasi), the frontalis, and the orbicularis. Under it lie the supra-orbital vessels and nerves.

The **procerus** (pyramidalis nasi) overlies the nasal bone. It arises from the lateral cartilage of the nose through a fibrous membrane and sometimes also directly from the nasal bone, and is attached to the skin over the root of the nose, where its fibres interdigitate with those of the frontalis. The medial margins of the muscles on each side are more or less fused.

Nerve-supply.—The muscles of this group are supplied by temporal branches of the facial nerve which enter the deep surfaces near the lateral margins.

Action.—The palpebral portion of the orbicularis closes the eyelids, of which the upper moves more freely than the lower. It also serves to dilate the lachrymal sac and allow the tears to flow away readily. The tensor tarsi probably contracts the sac and forces the tears into the nose. The upper half of the orbital portion of the orbicularis contracts and depresses the tissue overhanging the orbit, and stretches the skin of the forehead. The corrugator draws the skin of the brow downwards and medially, thus aiding the preceding muscle. It causes the perpendicular furrows characteristic of frowning. The procerus (pyramidalis nasi) draws down the skin of the forehead and wrinkles the skin across the root of the nose. The lower half of the orbital portion of the orbicularis raises the skin of the cheek, causing the wrinkles seen to radiate from the corner of the eye. The whole set of muscles comes into play in the forcible closure of the eyes. In case of violent expiratory efforts, as in shouting, sneezing, coughing, etc., the eye is thus usually forcibly closed. The pressure thus exerted on the eyeball prevents a too violent flow of blood to the vessels of the eye. Pressure is thought at the same time to be exerted on the lachrymal gland so as to cause the excessive flow of tears often experienced at such times.

Variations.—The muscles of this group vary in extent and differentiation, and may be more or less fused with one another or with neighbouring muscles. The orbital portion of the orbicularis, the corrugator, and the procerus have been found absent.

(*f*) THE EPICRANIAL MUSCULATURE

(Fig. 306)

The **epicranius** (occipito-frontalis) is formed of the two **frontal** muscles, which lie on each side of the forehead, the two **occipital** muscles, which occupy corresponding positions on the occipital bone, and of the epicranial aponeurosis, the **galea aponeurotica,** which extends between these. The muscles and the intervening aponeurosis lie between two layers of fascia, the external of which is fused to the skin, while the internal moves freely over the periosteum, to which it is loosely attached. Hæmorrhages and abscesses spread freely between the deep layer of fascia and the periosteum.

The **frontalis** is a large, thin muscle with convex upper and concave lower border. It arises from the epicranial aponeurosis midway between the coronal suture and the orbital arch, and is inserted into the skin of the eye-brow and of the root of the nose. The medial fibre-bundles take a sagittal direction; the lateral converge obliquely towards the brow. The medial margins of the muscles of each side are approximated near the attachment. The more medial fibre-bundles are continuous with those of the procerus (pyramidalis nasi) and the angular portion (levator labii superioris alæque nasi) of the quadratus labii superioris; the more lateral interlace with those of the corrugator and orbicularis muscles. The branches of the vessels and nerves of the frontal region pierce the muscle and are distributed between it and the skin.

The **occipitalis,** flat and quadrangular, lies on the occipital bone above the supreme nuchal line. It rises by tendinous fibres from the lateral two-thirds of this line and from the posterior part of the mastoid process of the temporal bone, and is inserted into the epicranial aponeurosis. The medial fibre-bundles run sagittally, while the lateral run obliquely forwards. The occipital artery and nerve lie between the muscle and the skin. The lateral border of the muscle comes in contact with the posterior auricular muscle. The muscles of each side are usually separated by a strip of aponeurosis.

The **galea aponeurotica** (epicranial aponeurosis) is a fibrous membrane which extends between the occipital muscles and from them anteriorly to the frontal muscles. In the area between these two sets of muscles it is composed largely of sagittally running fibres into which coronal fibres radiate from the region of the muscles of the ear. Between the two occipital muscles the aponeurosis is attached to the supreme nuchal line and external occipital protuberance. Laterally the fascia covering it is continued as a special investment of the auricular muscles, beyond which it is attached to the mastoid process, the zygoma, and to the external cervical and the masseteric fasciæ.

Nerve-supply.—The frontalis is supplied by the temporal branches of the facial nerve, the occipitalis by the posterior auricular nerve. The branches enter the deep surface of each of these muscles near its lateral border.

Action.—The occipitalis serves to draw back and to fix and make tense the epicranial aponeurosis. The frontalis, with its aponeurotic extremity fixed, elevates the brows and throws the skin of the forehead into transverse wrinkles as in the expression of attention, surprise, or horror. When both muscles contract forcibly there is, in addition, a tendency to make the hair stand on end because the hair-bulbs of the occipital region slant forwards, those of the frontal region backwards. The frontalis when fixed below serves to pull the scalp forwards.

Variations.—The occipitalis is occasionally absent, a condition normal in ruminants. The muscles of the two sides may be fused in the median line (normal in dogs). It may be fused with the posterior auricular. The frontalis is rarely missing. The muscle-fibres of the frontalis and occipitalis have been found continuous. The frontalis may send slips to the medial or lateral angles or the orbital arch of the frontal bone, to the nasal process of the maxilla, or to the nasal bone. The fibre-bundles of the frontalis may interdigitate across the median line.

The **transversus nuchæ**, or occipitalis minor, is a small muscle, frequently present (25 per cent., LeDouble), which runs from the occipital protuberance towards the posterior auricular muscle, with which it may be fused. It may lie over or under the trapezius.

(*g*) AURICULAR MUSCLES
(Fig. 306)

The intrinsic muscles of the auricle are described in Section VII. There are three 'extrinsic' auricular muscles which converge from regions anterior, superior, and posterior to the ear and are inserted into it.

The **auricularis anterior** (attrahens aurem) is a small, flat, triangular muscle which arises between the two layers of the fascia of the galea aponeurotica, extends over the zygomatic arch, and is attached to the ventral end of the helix. The fibre-bundles converge from the origin towards a tendon of insertion. The area of origin of this muscle is often marked by a fibrous band tangential to its component fibres. From this band muscle fibre-bundles radiate out towards the frontal region of the skull. To the muscle formed of these radiating fibres the names **epicranio-temporalis** (Henle) and **temporalis superficialis** (Sappey) have been given.

The **auricularis superior** (attollens aurem) is a large, thin, triangular muscle which, from its tendinous insertion on the eminence of the triangular fossa of the ear, radiates upwards into the fascia of the galea aponeurotica, between the layers of which it takes origin near the temporal ridge. It lies over the temporal fascia and the periosteum of the parietal bone.

The **auricularis posterior** (retrahens aurem) is a thin, band-like muscle which extends over the insertion of the sterno-cleido-mastoid from the base of the mastoid process and the aponeurosis of the sterno-cleido-mastoid muscle to the convexity of the concha, where it has a tendinous insertion. It is usually composed of two fasciculi, and is contained between two layers of fascia derived from the galea aponeurotica.

Nerve-supply.—The auricularis anterior and superior are supplied by the temporal branch of the facial, the auricularis superior and posterior by the posterior auricular branch. The twigs of supply run to the deep surface of the muscles.

Relations.—The superficial ascending branch of the auriculo-temporal nerve usually runs superficial to the anterior and superior auricular muscles. The superficial temporal vessels run at first beneath these muscles and the lateral expansion of the galea aponeurotica, then between the two fascial layers which enclose the muscles. Their branches of distribution finally come to lie between the muscles and aponeurosis and the skin. The posterior auricular artery and nerve usually run under cover of the auricularis posterior.

Action.—The anterior muscle is a protractor, the superior an elevator, and the posterior a retractor of the ear, but usually in man they are inactive.

Variations.—These muscles vary much in development. The most constant of them is the superior. The posterior frequently is increased in size and fused with the occipitalis, which originally was probably an ear muscle. From the anterior muscle a special deep fasciculus is occasionally isolated. Each of the muscles is occasionally, though rarely, absent, the anterior most frequently. An inferior auricular muscle is very rarely found in man, though present in many of the lower mammals.

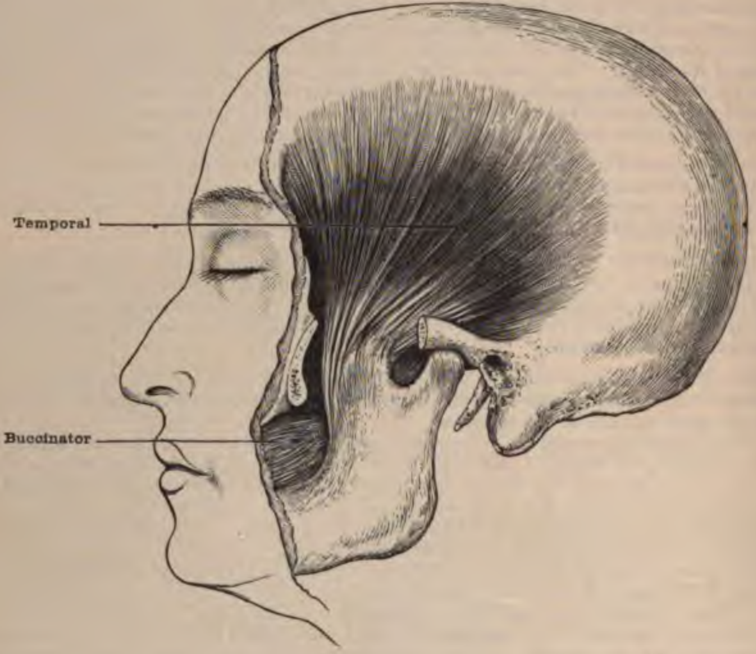
2. CRANIO-MANDIBULAR MUSCULATURE
(Figs. 308, 309, and 310)

The cranio-mandibular muscles, or muscles of mastication, pass from the base of the skull to the lower jaw. They are represented in some of the lower vertebrates by a single muscle mass, the adductor mandibulæ (Gegenbaur), but in the higher vertebrates this muscle mass becomes variously subdivided during embryonic development. The muscles are innervated by the fifth or trigeminal cranial nerve, the nerve of the mandibular arch. In man four muscles are recognised, the temporal, masseter, and internal and external pterygoids.

The **temporal** and **masseter** muscles are situated on the lateral surface of the skull, partly under cover of muscles of the facialis group. The **temporal** muscle (fig. 309), which resembles the quadrant of a circle, extends from the temporal fossa to the coronoid process of the mandible; the thick, quadrilateral **masseter** (fig. 308) muscle extends from the zygomatic arch to the lateral surface of the ramus and angle of the mandible. The **pterygoids** (fig. 310) are more deeply seated. The cone-shaped **external pterygoid** extends from the lateral side of the pterygoid process and lower surface of the great wing of the sphenoid to the condyloid process of the mandible and the capsule of the joint. The thick, quadrilateral **internal pterygoid** parallels the masseter and extends from the pterygoid fossa of the sphenoid to the inner side of the angle of the mandible. It will be noted that the temporal, masseter, and internal pterygoid muscles have approximately vertical axes of contraction and serve to adduct the lower jaw, while the external pterygoid has an approximately horizontal axis of contraction and serves to draw the jaw forwards and, when acting on one side, towards the opposite side.

The **temporal fascia** covers over the temporal fossa, in which lies the greater part of the temporal muscle. This fascia arises from the temporal line of the frontal bone and from the superior temporal line of the parietal and the periosteum immediately below this. It extends to the zygomatic arch. In its inferior quarter the fascia divides into two lamellæ, one of which passes to the outer, the other to the inner, surface of the arch, but at the superior margin of the arch these two lamellæ are united by dense fibrous tissue. Between the two lamellæ above the arch lies a fatty areolar tissue in which often runs the middle temporal artery. The outer surface of the fascia is covered by the superficial temporal and anterior and superior auricular muscles, and by a thin layer of fascia from the galea aponeurotica, with which, towards the zygomatic arch, it becomes merged. The superficial temporal artery and auriculo-temporal nerve cross it.

FIG. 309.—THE TEMPORAL MUSCLE.



The **masseteric fascia** represents essentially a continuation of the temporal fascia from the inferior margin of the zygomatic arch over the masseter muscle, which it covers. It is less thick than the temporal fascia, but is firm and strong. It is attached dorsally to the dorsal margin of the mandible, inferiorly to the inferior margin, and ventrally to the body and to the ventral margin of the ramus and the coronoid process of the mandible. The parotid gland, covered by the parotid extension of the external cervical fascia, extends over the posterior portion of this fascia. The **parotid fascia** becomes fused to its external surface at the anterior margin of the gland. Over it lie the parotid duct, the transverse facial artery, branches of the facial nerve, the zygomaticus (major), risorius, and platysma muscles.

The pterygoid muscles are each surrounded by a delicate membrane. In addition an **interpterygoid fascia** serves to separate the two muscles. This arises from the sphenoidal spine and follows the internal surface of the external pterygoid to the mandible. Medially it is attached to the lateral lamella of the pterygoid process; posteriorly and laterally it presents a free margin which forms with the neck of the mandibular condyle, an orifice for the passage of the internal maxillary artery, the auriculo-temporal nerve, and several veins. Its posterior margin is strengthened into the spheno-mandibular ligament, which runs from the spine of the sphenoid to the lingula of the mandible.

The pharyngeal region is separated from the pterygoid by a dense membrane, the **lateral pharyngeal fascia.** This extends from the depth of the pterygoid fossa to the prevertebral fascia, and separates the tensor palati from the internal pterygoid muscle. It is attached above along a line extending from the external margin of the carotid canal to the internal margin of the oval foramen.

The **sigmoidal septum** is a thin membrane which occupies the incisura mandibulæ and serves to separate the masseter from the external pterygoid muscle.

MUSCLES

The temporalis (fig. 309).—**Origin.**—(1) From the whole of the temporal fossa, with the exception of that part formed by the zygomatic (malar) bone; and (2) from the superior two-thirds of the fascia covering the fossa. **Insertion** is into the tip, dorsal and ventral borders, and the whole internal surface of the coronoid process of the mandible and the ventral portion of the medial surface of the ramus.

In *structure*, the muscle is thin near its superior margin, but becomes thick as its insertion is approached. The fibre-bundles arising from the medial surface of the fossa and from the fascia converge upon the medial and lateral surfaces and the margins of a thick, broad tendon which begins very high in the muscle, becomes visible laterally some distance above the zygomatic arch, and is inserted into the tip, edges, and internal surface of the coronoid process. On the ventral and dorsal margins of the tendon the insertion of fibre-bundles continues to the coronoid process, while medially the insertion of the fibre-bundles is continued on the medial surface of the coronoid process and often on the ramus as far as the body of the bone. The fasciculus arising from the arch is closely associated in origin with the masseter muscle, is separated by a pad of fat from the main body of the temporal muscle, and is inserted into the lateral surface of the lower extremity of the tendon of the temporal muscle and into the ventro-lateral surface of the tip of the coronoid process.

Nerve-supply.—Usually three branches from the anterior branch of the mandibular division of the fifth nerve curve upwards over the temporal surface of the great wing of the sphenoid and enter the deep surface of the muscle. The posterior and middle nerves, the former of which usually arises with the masseteric nerve, generally pass above the external pterygoid; the anterior, which springs from the buccinator nerve, passes between the two heads of the external pterygoid before curving upwards.

Relations.—The muscle is covered by the temporal fascia and the zygomatic arch. Below the temporal fossa the pterygoid muscles and the buccinator lie medial to it. The temporal fossa in front of the muscle is filled with a fatty areolar tissue and this also extends between the muscle and the temporal fascia. Fatty tissue likewise lies between the muscle and the buccinator. Medial to the muscle run the deep temporal vessels and nerves and the buccinator nerve. The masseteric nerve passes lateralwards behind and below the tendon.

The **masseter** (fig. 308) is composed of two layers. The **superficial layer** arises by an aponeurosis from the anterior two-thirds of the lower border of the zygomatic (malar) bone. The fibre-bundles arise from the deep surface of this aponeurosis and its tendinous prolongations, pass obliquely downwards and backwards, and are inserted into the lower half of the external surface of the ramus, into the angle, and into the neighbouring portion of the body of the mandible—the more anterior directly, the posterior by means of an aponeurosis. The **deep layer** arises from the lower border and internal surface of the zygomatic arch. The fibre-bundles pass nearly vertically downwards, and are inserted upon the upper half of the external surface of the ramus. The origin and insertion are by tendinous bands, to which the fibre-bundles are attached in a multipenniform manner. The two layers are fused near the origin and insertion and in front.

Nerve-supply.—The branch arises in common with the posterior nerve to the temporal muscle from the mandibular branch of the trigeminal. It passes above the external pterygoid, through the mandibular (sigmoid) notch, and enters the deep surface of the muscle near the dorsal margin.

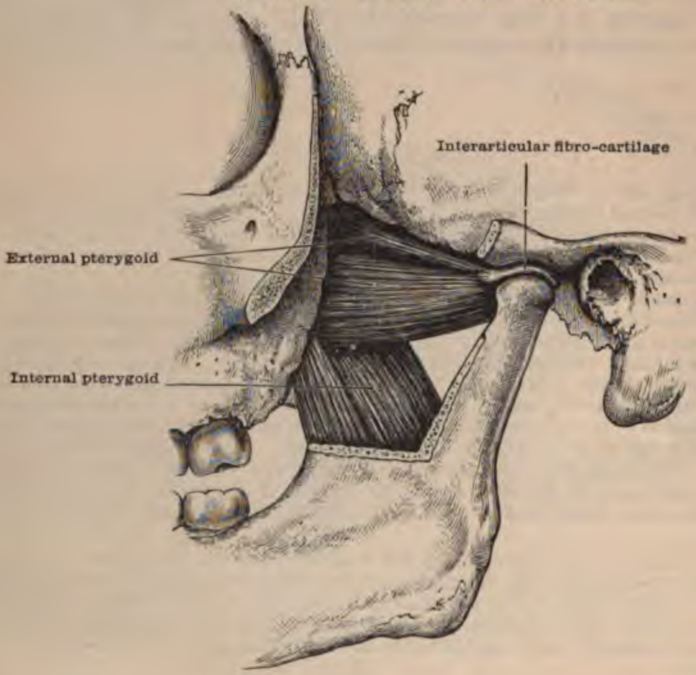
Relations.—It is covered by the masseteric fascia (see above). It lies upon the ramus of the jaw and ventrally is separated by a pad of fat from the buccinator muscle. At the mandibular (sigmoid) notch the sigmoid septum separates it from the external pterygoid muscle.

The **pterygoideus externus** (fig. 310) consists of two fasciculi. Each is thick and triangular. The superior is flattened in a horizontal, the inferior in a vertical, plane. At their origin they are separated by a narrow cleft. Near the insertion they become more or less fused. The **superior fasciculus** arises by short tendinous processes from the infratemporal (pterygoid) crest and from the neighbouring portion of the under surface of the great wing of the sphenoid. Its fibre-bundles converge towards the insertion, which takes place by short tendinous processes into—(1) the capsular ligament in front of the articular disc and (2) the upper third of the front of the neck of the condyle. The **inferior fasciculus** is the larger. It arises by short tendinous processes from the lateral surface of the lateral lamina of the pterygoid process, from the pyramidal process of the palate bone, and from the adjacent portions of the maxillary tuberosity. The fibre-bundles converge towards their insertion into a depression on the front of the neck of the condyle.

Nerve-supply.—As the buccinator nerve passes between the two fasciculi of the muscle it furnishes twigs to each. The nerve to the internal pterygoid may also furnish a branch to the muscle.

Relations.—It is partly covered by the maxillary fasciculus of the internal pterygoid and by the temporal and masseter muscles. Medial to it lies the chief fasciculus of the internal pterygoid muscle. The masseteric and the posterior and middle temporal nerves usually pass above the muscle, the anterior temporal and the buccinator nerves between the two fasciculi. The internal maxillary vessels usually pass below the lower border of the muscle and across its external surface; and the auriculo-temporal, lingual, and inferior alveolar (dental) nerves cross the deep surface of the muscle.

FIG. 310.—THE PTERYGOID MUSCLES.



The **pterygoideus internus** (fig. 310).—*Origin.*—From (1) the pterygoid fossa, and (2) from the maxillary tuberosity and the pyramidal process of the palatine, where these adjoin.

Structure and Insertion.—From the medial and lateral laminæ of the pterygoid process there arise aponeuroses and from the palatine bone at the lower margin of the fossa, and from the maxillary tuberosity and palatine bone in front of the external pterygoid, there arise short tendons. From these aponeuroses and tendons and directly from the fossa the fibre-bundles take a nearly parallel course downwards, backwards, and outwards, and are inserted in part in a multipenniform manner into the lower half of the internal surface of the ramus of the mandible. The insertion extends to the mylo-hyoid ridge. The muscle is divided at its origin into two fasciculi by the distal margin of the external pterygoid.

Nerve-supply.—The internal pterygoid nerve arises from the back of the mandibular nerve near the foramen ovale. It passes near or through the otic ganglion, and thence to the medial surface of the muscle near the dorsal edge. Both the buccinator and lingual nerves are also described as sending filaments to this muscle.

Relations.—Laterally the muscle is covered by the interpterygoid fascia and the spheno-mandibular ligament, the external pterygoid, temporal, and masseter muscles, and the ramus of the mandible. The inferior alveolar (dental) and lingual nerves and the corresponding vessels run across this surface. Medial to the muscle lie the lateral pharyngeal fascia, the tensor palati muscle, and the superior constrictor of the pharynx.

Action.—The muscles of this group adduct the lower jaw and serve to carry it forwards and backwards and from side to side. The elevation is produced by the masseter, temporal, and internal pterygoid muscles. The suprahyoid muscles and the external pterygoid are the feeble antagonists. The forward movement of the jaw is produced by the simultaneous action of the two external pterygoids, while the inferior dorsal portions of the temporal muscles serve to carry the jaw at the temporo-discoidal joint somewhat backwards. Lateral movements are produced chiefly by the action of one of the external pterygoids. The alternate action of these two muscles, associated with the elevating action of the other muscles of the group, gives rise to the grinding movement of the molar teeth.

Variations.—The temporal muscle may have a more extensive cranial origin than usual. It may be formed of two superimposed layers. It may be more or less fused with the external pterygoid, or send a fasciculus to the coronoid process. The masseter may be completely divided into two fasciculi, a condition normal in many mammals. A special fasciculus may arise from the temporo-mandibular articulation or from the zygomatic (malar) bone. Its deepest fibres may be fused with the temporal muscle. The two fasciculi of the external pterygoid may be distinct, as in the horse. It has been seen fused with the temporal and with the digastric muscle. The internal pterygoid may send a fasciculus to the masseter. It may give origin to the stylo-glossus. Inconstant fasciculi (*accessory pterygoids*) extending from the body of the sphenoid to the pterygoid process represent perhaps remnants of the muscles which act on the movable pterygoids possessed by many inferior vertebrates.

3. SUPERFICIAL AXIO-CINGULAR MUSCULATURE AND THE EXTERNAL CERVICAL FASCIA

(Figs. 312, 318)

The **sterno-cleido-mastoid** is a strong, band-shaped muscle, bifurcated below, which extends from the mastoid process of the temporal bone and the neighbouring part of the occipital to the medial third of the clavicle and the front of the manubrium. The large, flat, triangular **trapezius** extends from the occipital bone and the spines of the cervical and thoracic vertebræ to the lateral third of the clavicle and to the acromion and spine of the scapula. Both muscles serve to bend the head and neck towards the shoulder, rotate and extend the head, and raise the shoulder. The sterno-cleido-mastoid also serves to elevate the thorax and flex the neck.

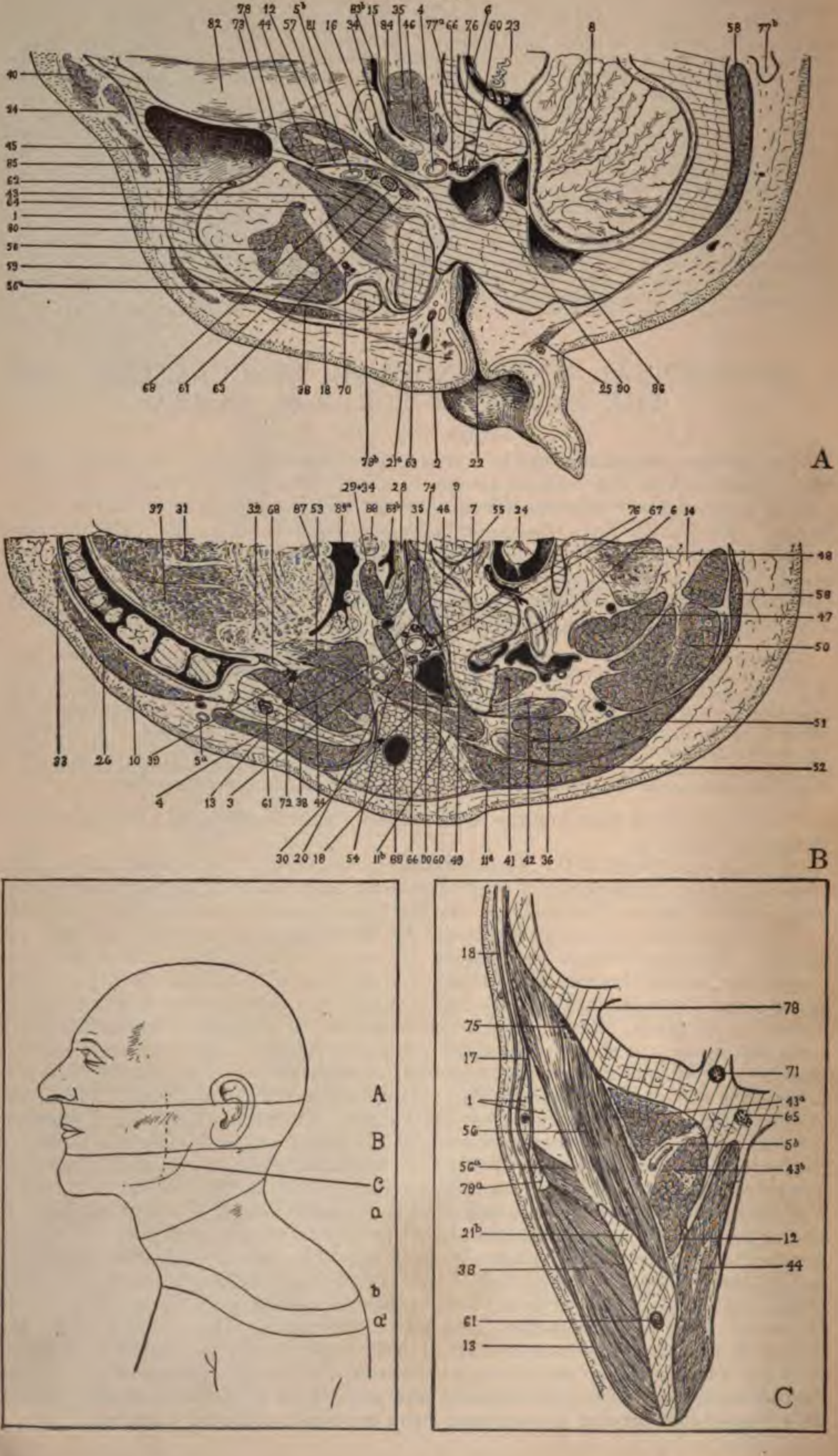
These two superficially placed muscles represent differentiated portions of a musculature found in elasmobranchs and in the amphibia and all higher vertebrates. In sharks this musculature does not extend to the head, but is associated with the musculature of the branchial arches, and, like them, is innervated by the vagus nerve. In the higher vertebrates it is innervated by the vagus or by the spinal accessory nerve, developed in connection with the vagus. To this innervation by a cranial nerve innervation by cervical nerves is added in those higher vertebrates in which the musculature is more extensively developed. In the human embryo the muscles migrate from their origin in the upper lateral cervical region to the positions found in the adult.

The fasciæ of the neck and the relations of the muscles are shown in cross-section in figs. 311 and 314.

The tela subcutanea of the head and neck has been briefly described above (p. 325). Over the upper dorsal region it is thick, fibrous, and closely adherent to the underlying muscle fascia. Ventrally in the cervical region it contains the platysma.

The superficial axio-cingular muscles are ensheathed by the **external cervical fascia.** This fascial layer lies beneath the subcutaneous tissue and the platysma, completely invests the neck and extends cranialwards over the parotid gland to the zygoma and the masseteric fascia. The trapezius lies between two closely adherent laminæ of the fascia. From the ventral margin of the trapezius it is continued as a thin but strong membrane across the posterior triangle of the neck, between this muscle and the sterno-cleido-mastoid, and is attached below to the clavicle. It invests the sterno-cleido-mastoid with two adherent laminæ and extends from the ventral margin of this muscle across the anterior triangle to the mid-line, where it is continued into that of the opposite side. In this triangle the fascia is bound to the hyoid bone, and is thus divided into a submaxillary and an infrahyoid portion. The **infrahyoid portion** is simple and is attached below to the front of the manubrium. The **submaxillary portion** is attached to the inferior margin of the mandible. It covers the submaxillary gland, and along the inferior margin gives rise to a strong, membranous process which passes inwards below the gland and, after extending around the tendon of the digastric muscle, becomes united to the superior margin of the hyoid bone. This process ventrally becomes fused with the perimysium of the ventral belly of the digastric. Dorsally it extends over the posterior end of the submaxillary gland and becomes attached to the angle of the jaw. Here it is strengthened by fibrous tissue which extends in from the ventral margin of the sterno-cleido-mastoid and serves to separate the parotid from the submaxillary gland. This 'mandibular process' is continued into the stylo-mandibular ligament.

FIG. 311.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13
C

The **parotid gland** is enclosed between two laminæ of the external cervical fascia. These are continued over the gland from the fascial investment of the sterno-cleido-mastoid, and unite ventrally to become fused to the masseteric fascia along the anterior margin of the gland. They unite below the inferior margin of the gland, and are continued into the mandibular process mentioned above. The external layer, which is the thicker and stronger, is attached above to the cartilage of the auditory canal and to the zygoma. The inner lamina is attached above to the base of the temporal bone. It is incomplete and is more or less fused to the posterior belly of the digastric muscle, the styloid process, and the muscles arising from this process. Between the styloid process and the angle of the jaw this lamina is strengthened to form the stylo-mandibular ligament.

In the back, beyond the spine of the scapula, the fascia arising from the investing adherent fascial sheath of the trapezius muscle is continued laterally across the fascia investing the infra-spinatus muscle, and becomes fused with the most superficial layer of this fascia and more distally with that of the latissimus dorsi muscle. Near this lateral line of fusion it is usually closely adherent to the tela subcutanea.

MUSCLES

(Fig. 312)

The **sterno-cleido-mastoideus** (fig. 312).—*Origin.*—By a medial (sternal) head from the front of the manubrium and by a lateral (clavicular) head from the upper border of the median third of the clavicle. Between the two origins there intervenes a triangular area covered by the external cervical fascia. Its *insertion* is—(1) on the anterior border and outer surface of the mastoid process, and (2) on the lateral half of the superior nuchal line of the occipital bone.

Structure.—The tendons are comparatively short, the longest being that on the anterior surface of the sternal attachment. The fibre-bundles of the muscle take a nearly parallel course from origin to insertion. Five fasciculi may be more or less clearly recognised. In a superficial layer—(1) a superficial sterno-mastoid; (2) a sterno-occipital; and (3) a cleido-occipital. In a deep layer—(4) a deep sterno-mastoid and (5) a cleido-mastoid.

Nerve-supply.—(1) From the spinal accessory nerve, which gives it branches during its course through the deep portion of the muscle, and (2) by branches from the anterior primary divisions of the second and third cervical nerves. These branches enter the deep surface of the upper half of the muscle.

FIG. 311.*—A AND B ARE TRANSVERSE SECTIONS AND C (AFTER TESTUT), A FRONTAL SECTION THROUGH THE LEFT SIDE OF THE HEAD, IN THE REGIONS INDICATED IN THE DIAGRAM.

a and *b* in the diagram indicate the regions through which pass sections A and B, fig. 314; and *a*, section A, fig. 320.

1. Adipose tissue. 2. Superficial temporal artery. 3. External carotid artery. 4. Internal carotid artery. 5*a*. External maxillary (facial) artery. 5*b*. Internal maxillary artery. 6. Vertebral artery. 7. Atlas. 8. Cerebellum. 9. Epistropheus (axis). 10. Bucco-pharyngeal fascia. 11*a*. Cervical fascia (superficial layer). 11*b*. Cervical fascia, deep parotid process. 12. Interpterygoid fascia. 13. Masseteric fascia. 14. Nuchal fascia. 15. Basilar pharyngeal fascia. 16. Lateral pharyngeal fascia. 17. Temporal fascia. 18. Galea aponeurotica. 19. Parotid gland. 20. Stylo-mandibular ligament. 21*a*. Mandible, capitulum. 21*b*. Coronoid process. 22. External acoustic meatus. 23. Medulla oblongata. 24. Spinal cord. 25. Auricularis posterior (retractor auris). 26. Buccinator. 27. Caninus (levator anguli oris). 28. Constrictor pharyngis medius. 29. Constrictor pharyngis superior. 30. Digastricus. 31. Genio-glossus. 32. Hyo-glossus. 33. Incisivus labii inferioris. 34. Levator veli palatini. 35. Longus capitis (rectus capitis anticus major). 36. Longissimus capitis (trachelo-mastoid). 37. Longitudinalis inferior. 38. Masseter. 39. Mylo-hyoideus. 40. Nasalis (alar portion). 41. Obliquus capitis inferior. 42. Obliquus capitis superior. 43. Pterygoideus externus—*a*, superior fasciculus; *b*, inferior fasciculus. 44. Pterygoideus internus. 45. Quadratus (levator) labii superioris. 46. Rectus capitis anterior (minor). 47. Rectus capitis posterior major. 48. Rectus capitis posterior minor. 49. Rectus capitis lateralis. 50. Semispinalis capitis (complexus). 51. Splenius capitis. 52. Sterno-cleido-mastoideus. 53. Stylo-glossus. 54. Stylo-hyoideus. 55. Stylo-pharyngeus. 56. Temporalis (*a*, fasciculus from zygoma). 57. Tensor veli palatini. 58. Trapezius. 59. Zygomaticus (major). 60. Spinal accessory nerve. 61. Inferior alveolar (dental) nerve. 62. Posterior superior alveolar (dental) nerve. 63. Auriculo-temporal nerve. 64. Buccinator nerve. 65. Vidian nerve. 66. Glosso-pharyngeal nerve. 67. Hypoglossal nerve. 68. Lingual nerve. 69. Mandibular nerve. 70. Masseteric nerve. 71. Maxillary nerve. 72. Mylo-hyoid nerve. 73. Palatine nerve. 74. Sympathetic trunk. 75. Deep temporal nerve. 76. Vagus nerve. 77. Occipital —*a*, basilar portion; *b*, external protuberance. 78. Sphenoid. 79. Temporal—*a*, processus zygomaticus; *b*, tubercle. 80. Zygomatic (malar). 81. Pharyngeal orifice of tuba auditiva (Eustachian tube). 82. Hard palate. 83. Pharynx—*a*, oral portion; *b*, nasal portion. 84. Pharyngeal recess. 85. Maxillary sinus (antrum of Highmore). 86. Transverse (lateral) sinus. 87. Palatine tonsil. 88. Uvula. 89. Posterior facial (temporo-maxillary) vein. 90. Internal jugular vein.

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* This and the following series of cross-sections are taken from a thin, not very muscular, adult male. The fasciæ are represented in most instances disproportionately thick.

Action.—To bend the head and neck towards the shoulder and rotate the head towards the opposite side. When both muscles act, the neck is flexed towards the thorax and the chin is raised; or, with fixed head, the sternum is raised, as in forced respiration. When the head is bent back, the two muscles may further increase the hyperextension.

Relations.—The muscle and its sheath are covered externally by the tela subcutanea, which here contains the platysma and the external jugular vein, as well as the superficial branches of the cervical plexus. Beneath the muscle lie the sterno-hyoid, sterno-thyreoid, omo-hyoid, levator scapulæ, scaleni, splenius, and digastric muscles, the cervical plexus, the common carotid artery, internal jugular vein, and the vagus nerve. The spinal accessory nerve usually runs through its deep cleido-mastoid portion.

Variations.—There is considerable variation in the extent of independence of the main fasciculi of the muscle In many of the lower animals the cleido-mastoid portion of the muscle is quite distinct from the sterno-mastoid portion, and this condition is frequently found in man. The cleido-occipital portion of the muscle is that most frequently absent (Wood found it present in 37 out of 102 instances). The clavicular portion of the muscle varies greatly in width. The sternal head has been seen to extend as far as the attachment of the fifth rib. Slips from the muscle may pass to various neighbouring structures. The main fasciculi of the muscle may be doubled. Sometimes one or more tendinous inscriptions cross a part or the whole of the muscle.

The **trapezius** (fig. 318).—*Origin.*—By a flat aponeurosis from the superior nuchal line and external protuberance of the occipital bone, the ligamentum nuchæ, and the vertebral spines and supraspinous ligament from the seventh cervical to the twelfth thoracic vertebra. The aponeuroses of the right and left muscles are continuous across the middle line. Between the middle of the ligamentum nuchæ and the second thoracic vertebra, the aponeuroses give rise to an extensive quadrilateral tendinous area. At the distal extremity of the muscle they are also well developed.

Structure and Insertion.—The superior fibre-bundles pass obliquely downwards, lateralwards, and forwards to the posterior border of the lateral third of the clavicle; the middle fibre-bundles, transversely to the medial edge of the acromion and the upper border of the spine of the scapula; the lower fibre-bundles, obliquely upwards and laterally to terminate through a flat triangular tendon on a tubercle at the medial end of the spine of the scapula.

Nerve-supply.—The external branch of the spinal accessory nerve descends for a distance near the superior border of the trapezius muscle and then along the ventral surface. Soon it gives rise to ascending branches for the superior portion of the muscle and descending branches for the middle and inferior portions. The main branches of distribution run about midway between the origin and insertion of the fibre-bundles. The branches from the third and fourth cervical nerves anastomose with the trunk of the spinal accessory, sometimes as it passes along the margin of the muscle, at other times within the substance of the upper portion of the muscle.[*]

Action.—When the whole muscle contracts, it draws the scapula towards the spine and turns it so that the inferior angle points laterally, the lateral angle upwards. In addition the upper portion draws the point of the shoulder upwards, and with the scapula fixed extends the head, bends the neck towards the same side, and turns the face to the opposite side. The lower portion of the muscle tends to draw the scapula downwards and inwards and at the same time to rotate the inferior angle of the scapula outwards.

Relations.—It is covered merely by skin and fascia. It lies external to the semispinalis, splenii, rhomboidei, latissimus dorsi, levator scapulæ, supraspinatus, and a small portion of the infraspinatus muscles.

Variations.—The distal limit of attachment of the muscle may be as high as the fourth thoracic vertebra. The right and left muscles are seldom symmetrical. The proximal attachment may not extend to the skull. The clavicular attachment may be much more extensive than normal or may be missing. The attachments to the scapula show considerable variations. Occasionally the cervical and thoracic portions are separate, a condition normal in many mammals. Ventrally the trapezius may become continuous with the sterno-cleido-mastoid in the neck, or send a fasciculus to it or to the sternum. Rarely a transverse tendinous inscription is found in the cervical portion of the muscle. Sometimes a fasciculus is sent into the deltoid (see p. 359). The *levator claviculæ* is a fasciculus frequent in the lower mammals, but rarely found in man. It usually extends from the acromial end of the clavicle to the atlas and axis, but may extend to more distal cervical vertebræ. It is innervated by a ramus from the cervical branches to the trapezius.

A **bursa** is often found between the spine of the scapula and the aponeurosis of the trapezius.

4. SUPRA-HYOID MUSCULATURE

(Fig. 312)

From the hyoid bone there extend to the base of the skull on each side four muscles which form a fairly well-defined group. They are situated external to the musculature of the tongue and pharynx, and serve to elevate the hyoid bone and larynx and to depress the mandible. The most superficial of the group is the slender, fusiform **stylo-hyoid,** which extends from the styloid process of the temporal bone to the hyoid. Immediately behind this is the flattened posterior belly of the **digastric,** which extends from the mastoid notch to a tendon that runs between two divisions of the tendon of the stylo-hyoid and is attached to the hyoid bone by an aponeurotic process. From the digastric tendon the flat, triangular anterior belly is continued to the back of the ventral portion of the inferior margin of the mandible. Internal to this anterior belly the thin, quadrangular **mylo-hyoid** radiates out from the hyoid bone to the inner surface of the body of the mandible, and still more internally the triangular **genio-hyoid** extends from the hyoid to the mental spine of the mandible. The motor innervation of the posterior belly of the digastric and of the stylo-hyoid is from the seventh cranial nerve, the sensory innervation probably from the ninth cranial nerve. The mylo-hyoid and the anterior belly of the digastric are supplied by the fifth cranial nerve; the genio-hyoid from the twelfth by a branch, the fibres of which are possibly derived through anastomosis from the first cervical nerve.

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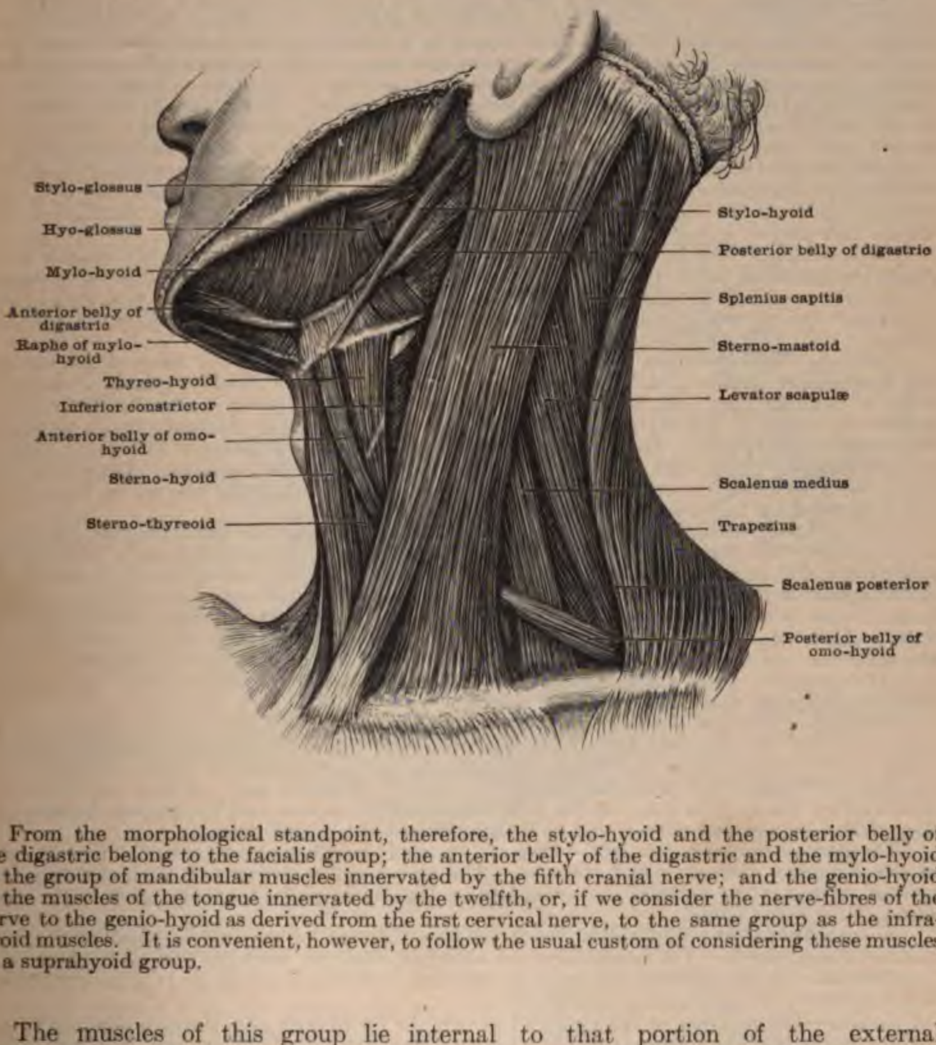
[*] According to Schulz, the spinal accessory supplies mainly the clavicular and lower scapular portions of the muscle, the cervical nerves mainly the acromial part.

FIG. 312.—ANTERIOR AND LATERAL CERVICAL MUSCLES.


Stylo-glossus
Hyo-glossus
Mylo-hyoid
Anterior belly of digastric
Raphe of mylo-hyoid
Thyreo-hyoid
Inferior constrictor
Anterior belly of omo-hyoid
Sterno-hyoid
Sterno-thyreoid
Stylo-hyoid
Posterior belly of digastric
Splenius capitis
Sterno-mastoid
Levator scapulæ
Scalenus medius
Trapezius
Scalenus posterior
Posterior belly of omo-hyoid

From the morphological standpoint, therefore, the stylo-hyoid and the posterior belly of the digastric belong to the facialis group; the anterior belly of the digastric and the mylo-hyoid to the group of mandibular muscles innervated by the fifth cranial nerve; and the genio-hyoid to the muscles of the tongue innervated by the twelfth, or, if we consider the nerve-fibres of the nerve to the genio-hyoid as derived from the first cervical nerve, to the same group as the infrahyoid muscles. It is convenient, however, to follow the usual custom of considering these muscles as a suprahyoid group.

The muscles of this group lie internal to that portion of the external cervical fascia which extends above the hyoid bone. This fascia, which is described on p. 337, comes into contact merely with the tendon, the anterior belly, and to a slight extent with the posterior belly of the digastric muscle. Above the tendon it sends inwards a process which curves down internal to the tendon, and is inserted into the external surface of the hyoid bone. The individual muscles of the group are covered by delicate adherent membranes. An aponeurotic membrane usually extends between the anterior bellies of the digastric muscles of each side.

MUSCLES

(Fig. 312)

The **stylo-hyoideus.**—*Origin.*—From the lateral and dorsal part of the base of the styloid process by a rounded tendon which soon becomes a hollow cone to the internal surface of which the fibre-bundles of the muscle are attached. *Structure and Insertion.*—The fibre-bundles are inserted on both sides of a slender tendon which divides to let the tendon of the digastric pass through and then is attached to the ventral surface of the body of the hyoid bone near its junction with the great cornu.

Nerve-supply.—From the facial nerve as it emerges from the stylo-mastoid foramen a small twig is given off which enters the proximal third of the deep surface of the muscle. The glosso-pharyngeal nerve also gives to it a small twig, probably sensory.

Relations.—It descends immediately in front of the posterior belly of the digastric. Externally lie the parotid and submaxillary glands. Medially it crosses the internal and external carotid arteries, branches of the ninth, tenth, and twelfth cranial nerves, the stylo-pharyngeus muscle, the superior constrictor of the pharynx, and the hyo-glossus muscle. The posterior auricular artery passes between it and the posterior belly of the digastric.

The **digastricus.**—The **posterior belly** arises by tendinous processes from the mastoid (digastric) notch of the temporal bone. The fibre-bundles form a ribbon-like belly which converges on the intermediate tendon. This begins as a semi-conical laminar process on the outer surface of the muscle a short distance above the hyoid bone. The **anterior belly** arises by short tendinous processes from the digastric fossa of the mandible. The fibres converge on both surfaces of the flattened anterior end of the intermediate tendon. The **intermediate tendon** lies a variable distance above the hyoid bone, usually less than a centimetre. It curves upwards towards each belly of the muscle. It is united to the outer surface of the body and the great cornu of the hyoid bone by an aponeurotic expansion from its inferior margin. Other expansions are usually continued into the interdigastric aponeurotic membrane. Occasionally the intermediate tendon of the digastric is bound to the hyoid bone by a fibrous loop which allows the tendon free play.

Nerve-supply.—The facial nerve near the stylo-mastoid foramen gives off a branch which enters the proximal third of the deep surface of the muscle. From this a ramus is continued through the muscle to the glosso-pharyngeal nerve. The anterior belly is supplied by a branch of the nerve to the mylo-hyoid muscle. This enters the middle of the lateral part of the deep surface.

Relations.—The posterior belly of the digastric lies internal to the mastoid process and the longissimus capitis (trachelo-mastoid), splenius, and sterno-cleido-mastoid muscles. It helps to form the deep wall of the cavity in which the parotid gland is placed. Internally it crosses the origin of the styloid muscles, the carotid arteries, the internal jugular vein, and the twelfth cranial nerve. The intermediate tendon of insertion lies below the inferior margin of the submaxillary gland, and crosses the hyo-glossus and mylo-hyoid muscles. The relations to the stylo-hyoid muscle have been described above. The anterior belly lies on the mylo-hyoid and is covered by the external cervical fascia and the platysma.

The **mylo-hyoideus.**—*Origin.*—From the mylo-hyoid ridge of the mandible. *Structure and Insertion.*—Its fibre-bundles take an oblique course and are inserted into—(1) a median raphe extending from the middle of the ventral surface of the hyoid done nearly or quite to the dorsal surface of the inferior margin of the mandible, and (2) into the ventral surface of the hyoid bone. Some of the fibre-bundles may cross the median line. The muscles of the two sides form a sheet with a downward convexity which lies between the inner surface of the body of the mandible and the hyoid bone. On the diaphragm thus formed rests the tongue.

Nerve-supply.—From the mylo-hyoid branch of the inferior alveolar (dental) nerve several filaments enter the under surface of the muscle.

Relations.—The mylo-hyoid muscle is covered externally by the submaxillary gland, the anterior belly of the digastric, and the external cervical fascia. It is crossed by the submental artery. With the genio-hyoid and the genio-glossus muscles it helps to bound a compartment in which are lodged the sublingual gland, the duct of Wharton, and the deep portion of the submaxillary gland. Its deep surface also faces the stylo-glossus and hyo-glossus muscles, the lingual and hypoglossal nerves, and to a slight extent the buccal mucosa.

The **genio-hyoideus** (fig. 313).—*Origin.*—By short tendinous fibres from the mental spine of the mandible. *Structure and Insertion.*—The fibre-bundles diverge and are inserted into the ventral surface of the body of the hyoid bone. Usually a special fasciculus goes to the great cornu of the hyoid bone.

Nerve-supply.—The hypoglossal nerve sends a filament to the middle third of the deep surface of the muscle. The nerve-fibres are said to be derived from the first cervical nerve.

Relations.—It lies between the genio-glossus and mylo-hyoid muscles. It adjoins its fellow of the opposite side and is often fused with it.

Action.—The muscles of this group all elevate the hyoid bone and, through this, the larynx and inferior part of the pharynx, and thus play a part in the act of swallowing. The stylo-hyoid and posterior belly of the digastric serve also to draw the hyoid bone in a dorsal direction; the ventral belly of the digastric and the genio-hyoid, in a ventral direction. The digastric, genio-hyoid, and mylo-hyoid depress the mandible. The posterior belly of the digastric has a slight power to bend the head backwards.

Variations.—The stylo-hyoid tendon frequently passes entirely in front of and less frequently entirely behind the digastric muscle. Its insertion may be of greater extent than usual. A special fasciculus to the lesser cornu is not very infrequent; more rarely one extends to the angle of the jaw or to other regions. The muscle may arise from the petrous portion of the temporal or from the occipital bone, as in some lower vertebrates. It may be absent, or fused with the posterior belly of the digastric. The anterior belly of the digastric may be missing; the posterior belly may be inserted into the angle of the jaw. The intermediate tendons of the digastric of each side may be connected by a fibrous arch. The anterior bellies of the muscles of each side may be united by a fasciculus or fused. The anterior belly is frequently doubled. The posterior belly may be divided by a tendinous inscription. Fasciculi may pass from either belly to neighbouring structures. The mylo-hyoid may not extend quite to the hyoid bone. It may be more or less fused with neighbouring muscles. Rarely it is absent. The genio-hyoid is frequently more or less fused with the muscles of the tongue or with the genio-hyoid of the opposite side.

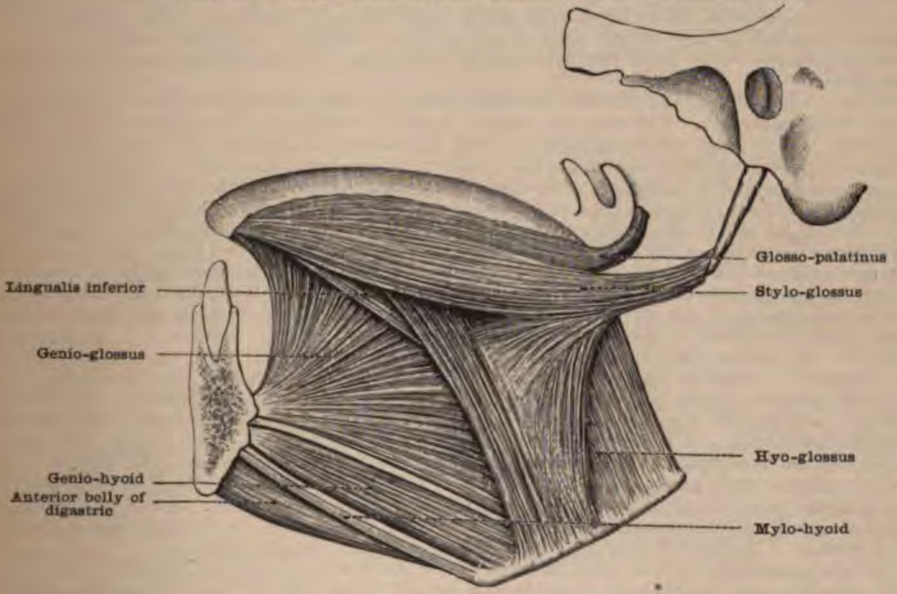
5. MUSCLES OF THE TONGUE

(Fig. 313)

The general structure of the tongue is described in Sec. VII. It is a flexible organ, composed chiefly of various muscles, some of which lie entirely within its substance, while others extend to be attached to neighbouring parts of the skeleton. To the former the term **intrinsic,** to the latter the term **extrinsic,** is frequently applied. In this section the extrinsic muscle will alone be taken up. The intrinsic muscles are described in the section on the TONGUE. Certain pharyngeal and palatal muscles which are continued into the tongue are described in connection with the pharynx. The extrinsic musculature of the tongue is concealed below by the suprahyoid musculature and the sublingual gland. It is covered on the free surface of the tongue by the mucosa.

The musculature of the tongue is supplied by the twelfth cranial nerve, which is in series with the motor roots of the spinal nerves. It is, primitively at least, derived from the ventral portion of myotomes in series with the spinal myotomes.

FIG. 313.—SIDE VIEW OF THE MUSCLES OF THE TONGUE.



Four extrinsic muscles are recognised on each side. The **stylo-glossus** is a slender muscle, which extends from the styloid process to the side of the tongue. It is cylindrical near its origin, flat and triangular near its insertion. The thin, quadrilateral **hyo-glossus** extends from the body and great cornu of the hyoid bone superficially over the posterior part to the dorsum of the tongue. The **chondro-glossus** extends from the lesser cornu of the hyoid bone to join the superior and inferior longitudinal muscles of the tongue. The **genio-glossus** (genio-hyo-glossus), which forms the main part of the body of the tongue, arises from the mental spine of the mandible, from which the fibre-bundles radiate out towards the whole length of the dorsum of the tongue and to the hyoid bone.

Under the mucous membrane of the tongue is a dense layer of fibrous tissue, the **lingual fascia.** In the body of the tongue there is a sagittal **septum linguæ,** which separates the two genio-glossus muscles. A transverse fibrous lamella, the **hyo-glossal membrane,** helps to unite the tongue to the hyoid bone. Delicate membranes invest the free portions of the extrinsic muscles of the tongue.

MUSCLES

The **stylo-glossus.**—This *arises* from the front of the lower end of the styloid process of the temporal bone and from the upper part of the stylo-mandibular ligament. *Insertion.*—It runs obliquely downwards, forwards, and medially, with slightly diverging fibre-bundles, to the lateral margin of the tongue, where it gives rise near the anterior pillar of the fauces to two fasciculi. The larger, lateral, longitudinal fasciculus runs superficially along the lateral margin of the tongue to the tip. The fibre-bundles are attached to the overlying mucosa and underlying musculature. The smaller, inferior, transverse fasciculus gives rise to diverging fibre-bundles which pass medially through the hyo-glossus into the base of the tongue. The most posterior of these diverging bundles may extend to the hyoid bone.

The **hyo-glossus.**—This *arises* from—(1) the lateral part of the ventral surface of the body of the hyoid bone and (2) from the upper border of the great cornu. The fibre-bundles take a nearly parallel course upwards, diverging, however, slightly. Near the upper margin of the back part of the tongue they curve medianwards and interlace with the intrinsic musculature of this region. The dorsal fibre-bundles pass transversely, the middle obliquely, the ventral longitudinally. They are inserted into the fibrous tissue which forms the skeletal framework of the tongue.

The **chondro-glossus** is a small muscle which arises from the lesser cornu of the hyoid bone and gives rise to fasciculi which join the longitudinalis inferior and the longitudinalis superior of the tongue described in Section VII.

The **genio-glossus.**—This *arises* from the mental (genial) spine of the mandible partly directly, partly by means of a short, triangular tendon. The more inferior fibre-bundles radiate towards the tip of the tongue; the intermediate extend directly towards the dorsum of the tongue, where they are *inserted* into the lingual fascia and skeletal framework. The inferior curve back to be inserted on the median part of the superior border of the hyoid bone.

Nerve-supply.—Twigs from the hypoglossal nerve enter the lateral surfaces of the muscles of this group.

Action.—The chief of the muscles, the genio-glossus, performs various services according to the part which contracts. The anterior portion serves to withdraw the tongue into the mouth and depress the tip; the middle portion to draw the base of the tongue forwards, depress the median portion of the tongue, and make the tongue protrude from the mouth; the inferior fibres to elevate the hyoid bone and carry it forwards. The stylo-glossus retracts the tongue, elevates its margin, and raises the hyoid bone and base of the tongue. The hyo-glossus draws down the sides of the tongue and is also a retractor. The chondro-glossus aids in both these movements.

Relations.—The main portion of the tongue is composed of the two genio-glossus muscles, which are separated in the median line by the lingual septum. The genio-glossus is covered inferiorly by the genio-hyoid and the mylo-hyoid muscles; along the lateral margin of the tongue by the glosso-palatinus, the stylo-glossus the longitudinalis inferior, and the glosso-pharyngeus muscles; and posteriorly by the hyo-glossus and the chondro-glossus. Below it forms a part of the medial wall of the space in which the sublingual gland is lodged. Over the dorsum and tip of the tongue it is covered by the mucosa. This likewise covers laterally, in the region of the base of the tongue, the stylo-glossus, hyo-glossus, and the longitudinalis inferior. The lingual artery runs between the hyo-glossus and the genio-glossus, and along the boundary between the longitudinalis inferior and the genio-glossus to the tip of the tongue. The lingual vein, which lies lateral to the hyo-glossus muscle, takes a similar although much more irregular course. The glosso-pharyngeal nerve passes down medial to the stylo-glossus muscle to the root of the tongue. The lingual nerve passes along the lateral margin of the tongue external to the stylo-glossus, hyo-glossus, and inferior longitudinal muscles. The hypoglossal nerve lies lateral to the inferior portion of the hyo-glossus muscle and then sinks into the genio-glossus.

The hyo-glossus muscle is covered laterally below the free portion of the tongue by the mylo-hyoid, digastric, and stylo-hyoid muscles and by the deep part of the submaxillary gland. Medially it covers in part the middle constrictor of the pharynx.

The stylo-glossus muscle above the tongue lies medial to the stylo-hyoid and the internal pterygoid muscles and the parotid gland, and between the internal and external carotid arteries. It lies lateral to the superior constrictor of the pharynx.

Variations.—The genio-glossus often sends a slip to the epiglottis (**levator epiglottidis**). It may send some bundles into the superior constrictor of the pharynx (**genio-pharyngeus**) or to the stylo-hyoid ligament. Various parts of the muscle may be more or less isolated. Of these, a fasciculus from the mental (genial) spine to the tip of the tongue is the most frequent (**longitudinalis linguæ inferior medius**). The hyo-glossus exhibits considerable variation in structure. Some authors consider the chondro-glossus but a portion of this muscle, while Poirier considers it merely the origin of the longitudinalis inferior. The stylo-glossus may be absent on one side or on both. Its origin varies considerably and may be from the angle of the jaw. The muscle may be doubled.

6. INFRAHYOID MUSCLES AND THE MIDDLE CERVICAL FASCIA

(Figs. 312 and 314)

The four infrahyoid muscles constitute a well-defined group which serves to depress the hyoid bone, the larynx, and the associated structures. They lie beneath the sterno-cleido-mastoid muscle and the external cervical fascia. Two strata may be recognised. In the superficial stratum are comprised the **omo-hyoid,** a narrow, ribbon-like digastric muscle which extends from the hyoid bone to the superior margin of the scapula; and the thin, quadrangular **sterno-hyoid,** which extends from the hyoid bone to the superior margin of the sternum and the medial end of the clavicle. Between these two muscles is an aponeurotic membrane which constitutes the main part of the middle layer of the cervical fascia, and represents possibly a retrograde portion of a single muscle, of which the two above named are but the ventral and dorsal margins. Below this superficial musculature the thin, quadrangular **thyreo-hyoid** descends from the hyoid bone to the thyreoid cartilage, and the ribbon-like **sterno-thyreoid** from the thyreoid cartilage to the sternum.

All these muscles are supplied by branches from the ansa hypoglossi. The nerve-fibres arise from the first three cervical nerves.

The muscles of this group are derived from the ventral portions of the ventro-lateral divisions of the first three cervical myotomes, and correspond with the rectus abdominis muscle, which is derived from the ventral portions of the eighth to the twelfth thoracic myotomes. This musculature is characterised by metameric segmentation, which may be more or less obscured, and by a general longitudinal direction taken by the component fibre-bundles. The course of the fibres in the omo-hyoid may be looked upon as a secondary condition due to the shifting laterally of the distal attachment of the muscle. Musculature of this nature is not derived from the lower cervical and upper thoracic myotomes in man, but in some of the lower vertebrates it forms a continuous ventral band. Even in man occasional traces of this ventral musculature may, however, be seen in the form of muscle and aponeurotic slips on the upper part of the thoracic wall, above the ribs and the aponeurosis of the external intercostal muscles.

Fascia (figs. 314 and 320)

The **middle cervical fascia** is composed of two laminæ. Of these, the superficial, which ensheaths the sterno-hyoid and omo-hyoid muscles and fills in the intervening area, is much the stronger and better differentiated. The more delicate deep lamina ensheaths the thyreo-hyoid and sterno-thyreoid muscles, and laterally extends out to become fused with the superficial lamina. It is also more or less closely bound to the sheath which covers the internal jugular vein, carotid artery, and vagus nerve.

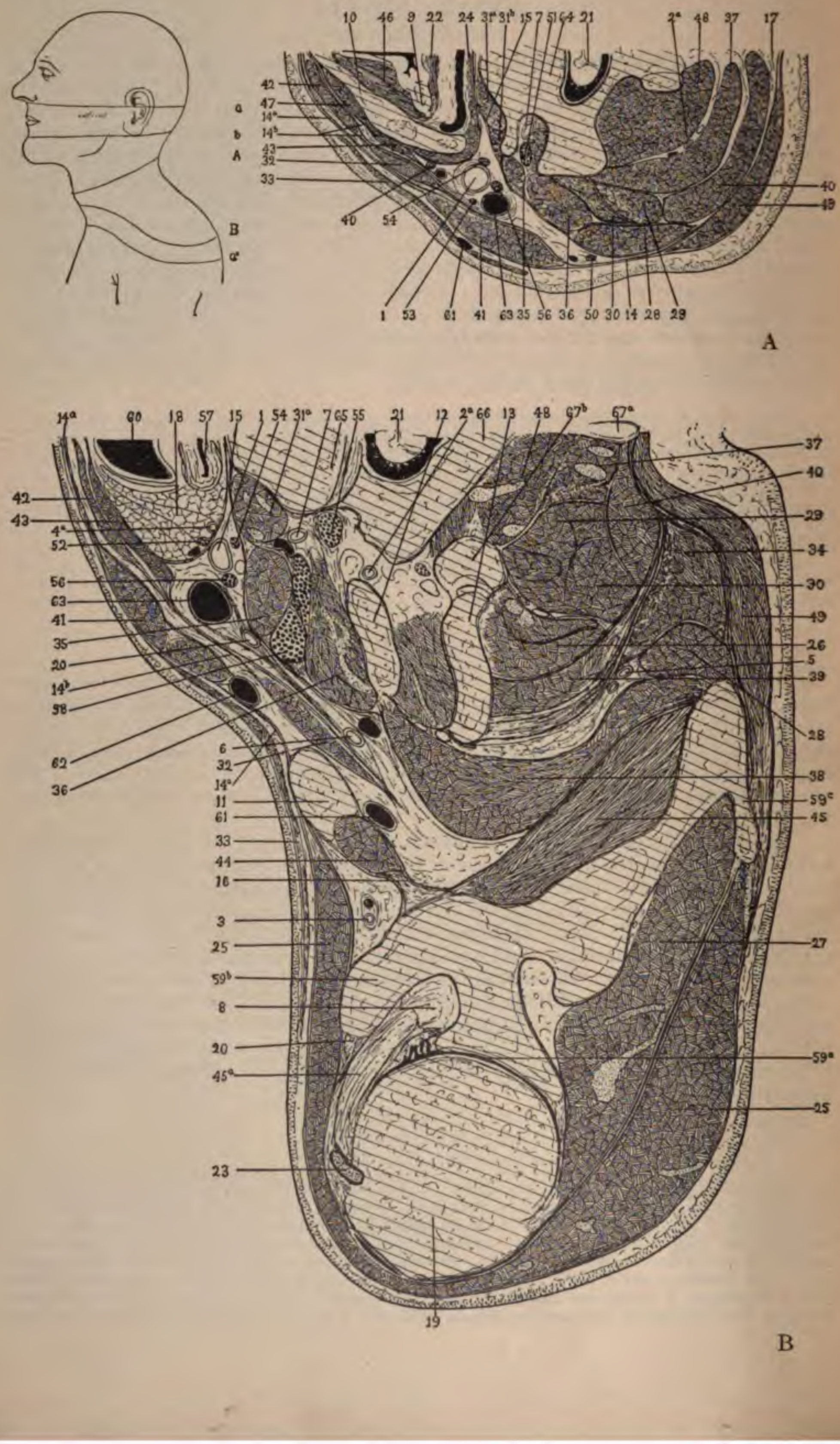
The middle cervical fascia is attached above to the hyoid bone. Beyond the lateral edge of the omo-hyoid it becomes fused with the deep lamina of the external layer of the cervical fascia, beneath the sterno-cleido-mastoid. Posterior to this muscle it usually terminates along the cranial margin of the omo-hyoid in the areolar tissue of the neck. Its distal attachment takes place into the dorsal surface of the upper margin of the sternum, and from here a process is sent over the left innominate vein to the pericardium. Lateral to the sternum the fascia is attached for some distance to the inner margin of the clavicle, and gives rise to processes, one of which extends to the fascia of the subclavius muscle, while the others pass on each side of the subclavian vein to the first rib. Still more laterally the fascia is fused along the lower margin of the scapular belly of the omo-hyoid to the underlying dense, fatty areolar tissue.

MUSCLES

(Figs. 312, 323)

The **sterno-hyoideus.**—*Origin.*—From (1) the deep surface of the medial extremity of the clavicle; (2) the costo-clavicular (rhomboid) ligament; and (3) the neighbouring part of the sternum. The origin may extend to the cartilage of the first rib. *Structure and Insertion.*—The fibre-bundles take a nearly parallel course upwards. The muscle belly, however, contracts slightly in width and increases slightly in thickness and slants somewhat towards the median line. The insertion takes place directly upon the inferior margin of the body of the hyoid. Not infrequently a tendinous inscription near the junction of the middle and inferior thirds more or less completely divides the muscle into two portions. *Nerve-supply.*—One or more

FIG. 314, A AND B.


a
b
A
B
a'
10
46
9
22
24
31a
31b
15
7
51
64
21
2a
48
37
17
42
47
14a
14b
43
32
33
40
54
40
49
1
53
61
41
63
35
56
36
50
30
14
28
29
A
14a
60
18
57
15
1
54
31a
7
65
55
21
12
2a
66
13
48
67b
67a
42
43
4a
52
56
63
41
35
20
14b
58
62
36
6
32
14a
11
61
33
44
16
3
25
59b
8
20
45a
23
19
37
40
29
34
30
49
26
5
39
28
38
59c
45
27
59a
25
B

branches from the ansa hypoglossi enter the lateral margin of the muscle. Frequently one goes to the upper third, another to the lower third, of the muscle.

The **omo-hyoideus.**—*Origin.*—From the superior margin of the scapula near, and occasionally also from, the superior transverse ligament of the scapula. *Insertion.*—The lower border of the hyoid bone lateral to the sterno-hyoid muscle. *Structure.*—The inferior belly of the muscle near its origin is thick and fleshy. It contracts as it passes ventrally across the posterior triangle of the neck. Beneath the sterno-cleido-mastoid it is attached to a short tendon from which, as it bends upwards towards the hyoid bone, the superior belly takes origin and thence expands towards the insertion. The tendon of attachment is short. The fibre-bundles of both bellies take a nearly parallel course. The central tendon of the muscle is held in place by a strong process in the middle layer of the cervical fascia. This process is attached to the dorsal surface of the clavicle and to the first rib. *Nerve-supply.*—The superior belly is supplied by a branch which enters its deep surface near the medial margin somewhat below the centre; the inferior by a branch which enters the proximal third of its deep surface. These branches arise from the ansa hypoglossi.

The **sterno-thyreoideus.**—*Origin.*—Partly directly, partly by tendinous fibres, from—(1) the dorsal surface of the manubrium from the middle line to the notch for the first rib; (2) the dorsal surface of the cartilage of the first rib. Occasionally also from the back of the cartilage of the second rib or from the clavicle. *Structure and Insertion.*—The fibre-bundles take a nearly parallel course upwards and slightly lateralwards. The muscle is inserted by short tendinous fibres into the oblique line on the lamina of the thyreoid cartilage. A transverse tendinous inscription not infrequently divides the belly of the muscle more or less completely into two parts. *Nerve-supply.*—By one or two branches from the ansa hypoglossi, which enter the ventral surface of the muscle near the lateral margin. One branch usually goes to the upper, another to the lower, third of the muscle.

The **thyreo-hyoideus.**—*Origin.*—From the oblique line on the lamina of the thyreoid cartilage. *Structure and Insertion.*—The fibre-bundles take a parallel course and are inserted on the inferior margin of the body of the hyoid bone and the external surface of the great cornu. Many fibre-bundles are continuous with those of the sterno-thyreoid. *Nerve-supply.*—By a branch of the hypoglossal which enters the deep surface of the muscle near the middle of its lateral border. The fibres are said to be derived from the first cervical nerve.

Action.—The sterno-hyoid and omo-hyoid serve to depress the hyoid bone; the sterno-thyreoid to depress the thyreoid cartilage; and the thyreo-hyoid to approximate the bone to the cartilage. The omo-hyoid tends to draw the hyoid bone somewhat laterally. In this it is aided by the digastric and stylo-hyoid and is opposed by the sterno-thyreoid and thyreo-hyoid muscles.

Relations.—The muscles of this group lie beneath the external cervical fascia. The sterno-cleido-mastoid muscle crosses the omo-hyoid, the sterno-hyoid, and sterno-thyreoid muscles. The two latter muscles extend for a distance behind the manubrium of the sternum. The omo-hyoid is partly covered by the trapezius, crosses the scalene muscles, the brachial plexus, the internal jugular vein, carotid artery, and the sterno-thyreoid and thyreo-hyoid muscles. The sterno-hyoid extends over the sterno-thyreoid muscle, the thyreoid gland, crico-thyreoid muscle, and the thyreoid cartilage. The sterno-thyreoid lies over the innominate vein, the trachea, and thyreoid gland. It is partly covered by the sterno-hyoid and omo-hyoid muscles. The thyreo-hyoid is largely covered by the omo-hyoid and sterno-hyoid muscles, and lies upon the hyo-thyreoid membrane and the upper part of the thyreoid cartilage.

Variations.—The muscles vary in extent of development and may be more or less fused with one another. The sternal attachment of the sterno-hyoid is more frequently absent than the clavicular attachment. The region between the omo-hyoid and sterno-hyoid may be com-

Fig. 314, A and B.—TRANSVERSE SECTIONS THROUGH THE LEFT SIDE OF THE NECK AND SHOULDER IN THE REGIONS INDICATED IN THE DIAGRAM.

a and *b* in the diagram indicate sections A and B of fig. 311 (p. 338). *a*, that of section A, fig. 320 (p. 358).

1. Common carotid artery. 2*a*. Deep cervical artery. 2*b*. Superficial cervical artery. 3. Thoraco-acromial artery (acromial branch). 4*a*. Inferior thyreoid artery. 4*b*. Superior thyreoid artery. 5. Transversa colli artery. 6. Transverse scapular artery. 7. Vertebral artery. 8. Bursa m. subscapularis. 9. Arytenoid cartilage. 10. Thyreoid cartilage. 11. Clavicle. 12. I. rib. 13. II. rib. 14*a*. Cervical fascia (superficial layer). 14*b*. Cervical fascia (middle layer). 15. Cervical fascia (deep or prevertebral layer). 16. Coraco-clavicular fascia. 17. Nuchal fascia. 18. Thyreoid gland. 19. Humerus. 20. Coraco-humeral ligament. 21. Spinal cord. 22. Arytenoideus transversus. 23. Biceps brachii, tendon long head. 24. Constrictor pharyngis inferior. 25. Deltoideus. 26. Ilio-costalis. 27. Infraspinatus. 28. Levator scapulæ. 29. Longissimus capitis (trachelo-mastoid). 30. Longissimus cervicis. 31*a*. Longus colli. 31*b*. Longus capitis (rectus capitis anticus major). 32. Omo-hyoideus. 33. Platysma. 34. Rhomboideus minor. 35. Scalenus anterior. 36. Scalenus medius. 37. Semispinalis capitis (complexus). 38. Serratus anterior. 39. Serratus posterior superior. 40. Splenius. 41. Sterno-cleido-mastoideus. 42. Sterno-hyoideus. 43. Sterno-thyreoideus. 44. Subclavius. 45. Subscapularis. 45*a*. Tendon. 46. Thyreo-arytenoideus (and vocalis). 47. Thyreo-hyoideus. 48. Transverso-spinales. 49. Trapezius. 50. Spinal accessory nerve. 51. IV. cervical nerve. 52. Inferior laryngeal nerve. 53. Descendens hypoglossi. 54. Sympathetic trunk. 55. I. thoracic nerve. 56. Vagus nerve. 57. Œsophagus. 58. Brachial plexus. 59. Scapula—*a*, glenoid cavity; *b*, coracoid process; *c*, spine. 60. Trachea. 61. Transversa colli vein. 62. External jugular. 63. Internal jugular. 64. V. cervical vertebra. 65. VII. cervical vertebra. 66. I. thoracic vertebra, arch. 67. II. thoracic vertebra—*a*, spine; *b*, transverse process.

posed of muscle instead of fascia. Each of the muscles may be longitudinally divided into two distinct fasciculi, may send fasciculi to one another or to the middle layer of the cervical fascia, or may have an abnormal origin or insertion. The omo-hyoid is the only one of the group frequently absent. One of the bellies is much more frequently absent than both. The intermediate tendon of the omo-hyoid may be reduced to a tendinous inscription or even disappear entirely. The distal attachment may take place on the scapular spine, the acromion, the coracoid process, or even the first rib or clavicle. An extra fasciculus from the clavicle is found in 3 per cent. of instances. (Le Double.)

BURSÆ

The **bursa m. sterno-hyoidei** is inconstantly found between the lower margin of the hyoid bone and median hyo-thyreoid ligament and the sterno-hyoid muscle and external cervical fascia. It is better developed in men than in women and is found either on each side of the median line or fused in the median line.

The **bursa m. thyreo-hyoidei** is frequently found between the greater cornu of the hyoid bone and hyo-thyreoid membrane and the thyreo-hyoid muscle.

7. SCALENE MUSCULATURE

(Figs. 312 and 315)

The three muscles which form this group constitute a triangular mass which extends in front of the levator scapulæ and intrinsic dorsal musculature and behind the prevertebral musculature from the first two ribs to the transverse processes of the cervical vertebræ. They serve to bend the neck and to fix the first two ribs or raise the thorax. In front lies the **scalenus anterior,** which extends from the first rib to the fourth to sixth vertebræ. Behind this the **scalenus medius** extends from the first rib to the lower six vertebræ. The most dorsal of the group, the **scalenus posterior,** extends from the second rib to the lower four vertebræ.

These muscles are supplied by direct branches of the cervical nerves. They are probably derived from the lateral portions of the cervical myotomes. According to Gegenbaur, the two more ventral are homologous with intercostal muscles, the dorsal with the levatores costarum. It is to be noted, however, that the anterior muscle lies in front of the brachial plexus, i. e., in a position similar to that of the subcostal musculature.

FASCIA (figs. 314, 320)

From the front of the bodies of the cervical vertebræ the prevertebral fascia is continued laterally over the longus colli and the scalene muscles, and extends dorsally into the fascia covering the levator scapulæ. Between the muscles fascial processes are sent in to become attached to the cervical vertebræ.

MUSCLES

(Fig. 315)

The **scalenus anterior.**—This *arises* from the tip and inferior border of the anterior tubercles of the transverse processes of the fourth, fifth, and sixth cervical vertebræ, often from the third, rarely from the seventh, by means of long, slender tendinous processes. From each tendon arises a fasciculus composed of nearly parallel fibre-bundles. The fasciculi soon fuse to form a muscle belly which contracts somewhat towards the insertion. This takes place by means of a tendon which sends a fibrous lamina a short distance upwards on the outer surface of the muscle. The tendon is *inserted* into the scalene tubercle on the upper surface of the body of the first rib.

The **scalenus medius.**—This *arises* usually from the second to the seventh, sometimes from all seven or from merely the last four or five cervical vertebræ. The origin takes place from the lateral border and the concavity of the sulci of the transverse processes by means of a slender tendon from each of the upper and directly by a muscular fasciculus from each of the lower vertebræ. The fasciculi become combined into a compact muscle belly which is *inserted* in a manner similar to the scalenus anterior into the upper surface of the first rib behind the subclavian groove.

The **scalenus posterior.**—This is composed of two heads, one superficial, slender, and long, the other deep, thick, and short.

The **superficial head** *arises* by short tendons from the posterior tubercles of the transverse processes of the fourth, fifth, and sixth cervical vertebræ. The origin may be reduced to the fifth and sixth or to the sixth and seventh. It is inserted by a short tendon into the lateral surface of the second rib. Occasionally it extends to the third rib.

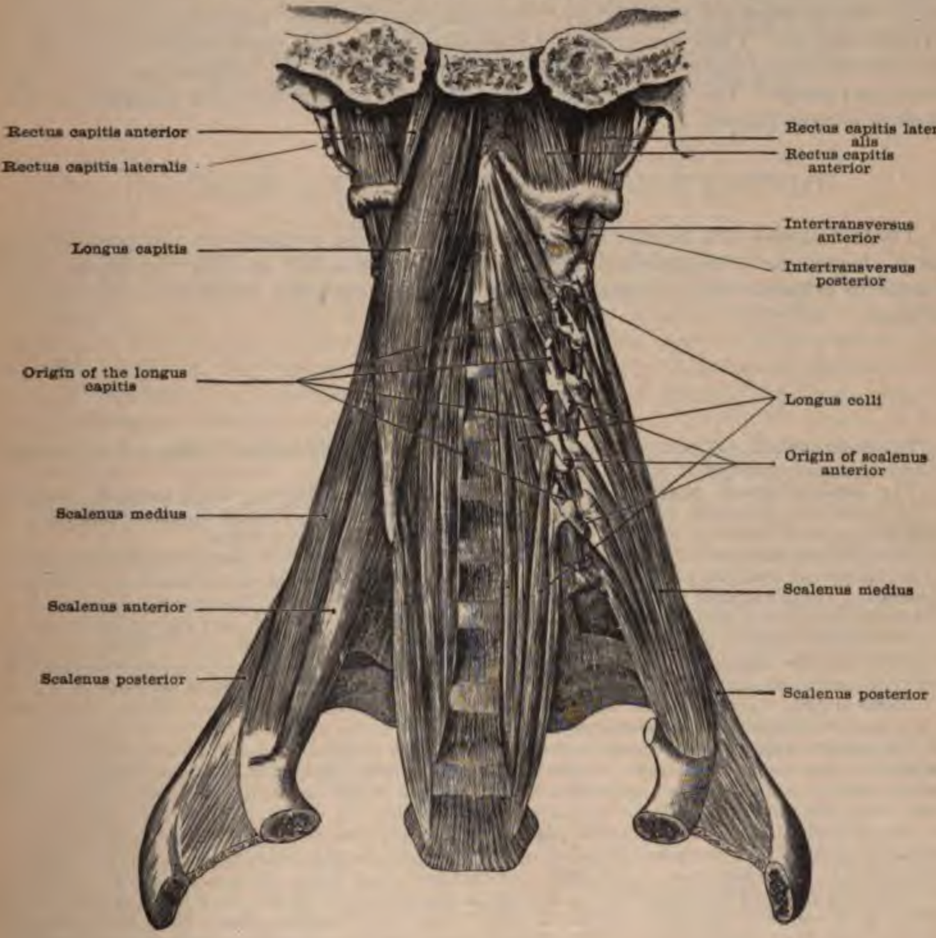
The **deep head** *arises* from the posterior tubercle and the intertubercular sulcus of the seventh cervical vertebra. It is *inserted* into the lateral surface of the first rib. It is not constant.

Nerve-supply.—The scalenus anterior is innervated by branches from the third, fourth, and fifth cervical nerves; the middle and posterior by the third, fourth, fifth, sixth, and seventh cervical nerves.

Action.—With the thorax fixed the scalene muscles bend the neck to the side and slightly forwards and turn it slightly towards the opposite side. With the neck fixed they serve to lift the first two ribs and are of use in enforced inspiration. In quiet inspiration they serve to fix the first two ribs.

Relations.—The longus colli lies medial to the scalenus anterior. Dorsally these muscles; medially the pharynx, thyreoid gland, and trachea; ventro-laterally the sterno-cleido-mastoid, infra-hyoid, and subclavius muscles and the clavicle bound a space filled with dense fatty areolar tissue in which are contained the subclavian and carotid arteries, the subclavian and internal jugular veins, the vagus, phrenic, and sympathetic nerves, and numerous smaller blood-vessels and nerves. The main branches of the lower five cervical nerves pass laterally between the scalenus anterior and medius. The subclavian artery passes behind, the subclavian vein in front, of the attachment of the scalenus anterior. The scalenus medius above and the scalenus posterior below enter into relations dorsally with the levator scapulæ and the intrinsic dorsal musculature, from which they are separated by fascial septa.

FIG. 315.—THE DEEP VENTRAL MUSCLES OF THE NECK.


Rectus capitis anterior
Rectus capitis lateralis
Longus capitis
Origin of the longus capitis
Scalenus medius
Scalenus anterior
Scalenus posterior
Rectus capitis lateralis
Rectus capitis anterior
Intertransversus anterior
Intertransversus posterior
Longus colli
Origin of scalenus anterior
Scalenus medius
Scalenus posterior

Variations.—The scaleni present numerous variations in the extent of the costal and vertebral attachments. The degree of fusion of the various fasciculi likewise varies so much that different authors have described varying numbers of muscles into which the scalenus mass should be subdivided. A muscle frequently present is the **scalenus minimus.** This arises from the anterior tubercle of the sixth or sixth and seventh cervical vertebræ, and is inserted into the first rib behind the sulcus for the subclavian artery. It sends a process (Sibson's fascia) to the pleural cupola and serves to make the pleura tense. Zuckerkandl found it in 22 out of 56 bodies. When absent, a ligamentous band takes its place.

8. THE PREVERTEBRAL MUSCULATURE

(Fig. 315)

This deep-seated musculature extends along the ventro-lateral surfaces of the three upper thoracic and the cervical vertebræ to the skull. It is composed of three muscles. The **longus colli** arises from the bodies of the three thoracic and from the bodies and transverse processes of the third to the sixth cervical vertebræ, and is inserted into transverse processes of the lower six cervical vertebræ. The **longus capitis** (rectus capitis anterior major) extends from the transverse processes of the fourth, fifth, and sixth cervical vertebræ, and is inserted into the basilar process of the occipital bone. The **rectus capitis anterior** (minor) extends from the atlas to the base of the occipital bone. These muscles serve to flex and rotate the head and neck. All of them are supplied by direct branches from the anterior divisions of the cervical nerves. They are probably specialised from the ventro-lateral portions of the cervical myotomes. Similar muscles are found in all vertebrates with well-developed necks. The rectus capitis anterior (minor) represents an anterior cervical intertransverse muscle.

FASCIA (figs. 314, 320)

These muscles are firmly bound to the vertebral column by the prevertebral fascia described in connection with the scalene muscles and by the septa which extend in between the muscles of this group and between them and the scalenus anterior.

MUSCLES

(Fig. 315)

The **longus colli.**—The complex construction of this muscle makes it advisable to consider it as divided into three parts.

The **supero-lateral portion** consists of fasciculi which arise from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ and become fused into a belly which is inserted into the anterior tubercle of the atlas.

The **median portion** is formed of muscle fasciculi which arise from the antero-lateral parts of the bodies of the first three thoracic vertebræ and the last three cervical vertebræ by tendinous processes. These fasciculi fuse into a belly which terminates by three flat tendinous fasciculi on the antero-lateral surfaces of the bodies of the second, third, and fourth cervical vertebræ.

The **infero-lateral portion** is applied to the inferior lateral surface of the median portion. It arises from the lateral parts of the bodies of the first three thoracic vertebræ and is inserted by tendinous processes into the transverse processes of the fifth and sixth cervical vertebræ.

Nerve-supply.—By branches from the second to sixth cervical nerves which send rami to the various constituent fasciculi of the muscle.

The **longus capitis** (rectus capitis anterior major).—*Origin.*—By cylindrical tendons from the tips of the anterior tubercles of the third, fourth, fifth, and sixth cervical vertebræ. The tendons send up aponeurotic expansions on the outside of the fasciculi, which arise from them. These fasciculi fuse into a dense muscular belly to which is usually added a fasciculus from the longus colli. The *insertion* takes place into the impression on the inferior surface of the basilar process of the occipital bone, extending lateral to the pharyngeal tubercle outwards and forwards. The insertion of the fibre-bundles from the third vertebra is direct; the other fibre-bundles are inserted largely into a tendinous lamina which covers the middle of the ventral surface of the muscle and from which, in turn, other fibre-bundles arise. It is an incomplete digastric muscle. *Nerve-supply.*—The second, third, and fourth cervical nerves send branches into the ventral surface of the muscle.

The **rectus capitis anterior** (minor).—This *arises* from the upper surface of the lateral mass of the atlas in front of the articular process and partly from the neighbouring transverse process. From a tendon the fibre-bundles extend in a nearly parallel direction upwards and inwards to be *inserted* on the inferior surface of the basilar process of the occipital bone in front of the condyle. *Nerve-supply.*—From the first and second cervical nerves.

Action.—The longus capitis (rectus capitis anterior major) and rectus capitis anterior (minor) serve to bend the head forwards and, when the muscles on one side only are contracted, to rotate the head towards the same side. The longus colli serves to bend the neck forwards; the supero-lateral portion, when acting on one side only, serves slightly to bend the neck towards that side and to rotate it; the infero-lateral portion serves especially to prevent hyperextension.

Relations.—The muscles of this group are closely applied to the vertebral column. Between the fascia covering them and the fascia surrounding the pharynx which lies in front is a region in which merely a slight amount of loose areolar tissue is found. Dorso-medially the longus colli below and the longus capitis above help to bound the space in which the chief vessels and nerves extend between the thorax and the head.

Variations.—There is considerable variation in the number of vertebræ to which the tendons of origin and insertion of these muscles may be attached and in the extent of fusion of the different fasciculi composing them. There may be fusion with the scalenus anterior.

9. ANTERIOR INTERTRANSVERSE MUSCLES

(Fig. 315)

The anterior intertransverse muscles extend successively between the anterior tubercles of the cervical vertebræ. They lie in front of the anterior divisions of the cervical nerves and are supplied by branches from these divisions. They are usually more or less bound up with the insertions of the scalene and prevertebral muscles into these tubercles. The muscle between the atlas and epistropheus is frequently missing; when present, it passes in front of the lateral articulation between these vertebræ. The rectus capitis anterior (minor) may be considered a continuation of the series. The lowest muscle may extend between the seventh cervical vertebra and the first rib. For the posterior intertransverse muscles see p. 409.

10. DEEP AXIO-CINGULAR MUSCULATURE

(Figs. 312, 316, 317, 349)

To this group belong four muscles which arise in the lateral cervical region during embryonic development and become secondarily attached to the vertebral margin of the scapula. One of these muscles, the band-like **levator scapulæ** (fig. 316), remains in the cervical region. It extends beneath the sterno-cleido-mastoid, the trapezius, and the intervening fascia from the transverse processes of the first four cervical vertebræ to the medial angle of the scapula. A second, the large, quadrilateral **serratus anterior** (magnus) (fig. 317), comes to lie below the blade of the scapula and wanders with this to the thoracic region. It extends, in the adult, from the first nine ribs to the vertebral margin of the scapula. The flat, quadrangular **rhomboideus major** and **rhomboideus minor** (fig. 316) extend in the adult obliquely upwards across the deep dorsal muscles beneath the trapezius from the vertebral margin of the scapula to the upper thoracic and lower cervical spines. The third to the seventh cervical nerves give rise to branches which supply this set of muscles. The levator scapulæ is supplied by the most cranial of this group of nerves, the serratus anterior by the most caudal, while the supply to the rhomboids is intermediate between these. The muscles of this group serve to elevate the scapula, to rotate it, and to draw it backwards (rhomboidei) or forwards (serratus anterior).

The levator scapulæ and the serratus anterior (magnus) are two differentiated parts of a muscle which is a continuous mass in many of the lower mammals. A muscle corresponding to the rhomboideus is found in some of the reptiles and many of the higher vertebrates. In some of the mammals it has a more extensive cervical attachment than in man.

The **fasciæ** investing these muscles are shown in cross-section in Fig. 320.

The levator scapulæ is invested by fascial membranes, the external and stronger of which is continued dorsally from the fascial investment of the scalene muscles. The thinner layer on its deep surface lies next the fascial investment of the intrinsic muscles of the back. Cranialwards from the rhomboid muscles the fascial investment of the levator scapulæ is fused dorsally with the fascia covering the splenius cervicis. Where the dorsal margin of the levator comes in contact with the rhomboideus minor, the fascia is continued over into the thin fascial membrane which invests both surfaces of the rhomboidei. Similarly the investing fascia of the levator is continued ventrally into the fascia investing both surfaces of the serratus anterior (magnus). Within the internal fascial investment of this group of muscles, near the insertion of the levator, run the transversa colli artery and the dorsal scapular nerve.

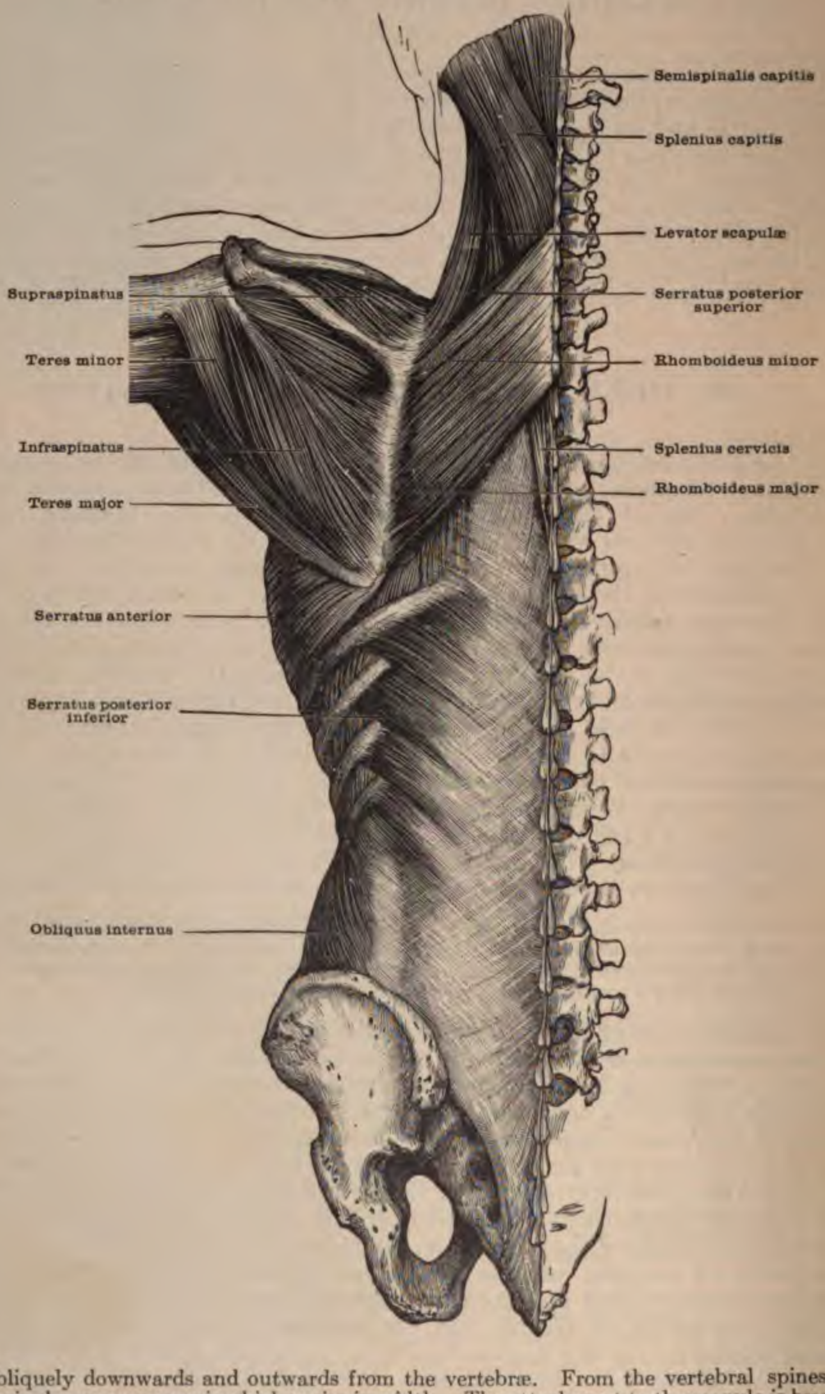
MUSCLES

The **rhomboideus minor** (fig. 316).—*Origin.*—Lower part of the ligamentum nuchæ, the spines of the seventh cervical and first thoracic vertebræ, and the intervening supraspinous ligament. *Insertion.*—Vertebral border of the scapula near the spine.

The **rhomboideus major** (fig. 316).—*Origin.*—Spines of the first four or five thoracic vertebræ. *Insertion.*—Vertebral border of the scapula opposite the infraspinous fossa.

Structure.—The two muscles are included between two adherent fascial layers which bridge over the greater or less space that may intervene between them. The fibre-bundles take a parallel course obliquely downwards and outwards from the vertebræ. From the vertebral spines the muscles arise by an aponeurosis which varies in width. The attachment to the scapula is by short tendinous processes. The attachment of the rhomboideus major is firmest towards the inferior angle of the scapula.

Fig. 316.—The Levator Scapulæ and Rhomboidei.


Semispinalis capitis
Splenius capitis
Levator scapulæ
Supraspinatus
Serratus posterior superior
Teres minor
Rhomboideus minor
Infraspinatus
Splenius cervicis
Teres major
Rhomboideus major
Serratus anterior
Serratus posterior inferior
Obliquus internus

Nerve-supply.—The dorsal scapular nerve, which usually arises from the fourth or fifth cervical nerve, enters the superior margin of the rhomboideus minor and then courses distally near the deep ventral surface of the two muscles and about midway between the tendons of origin and insertion.

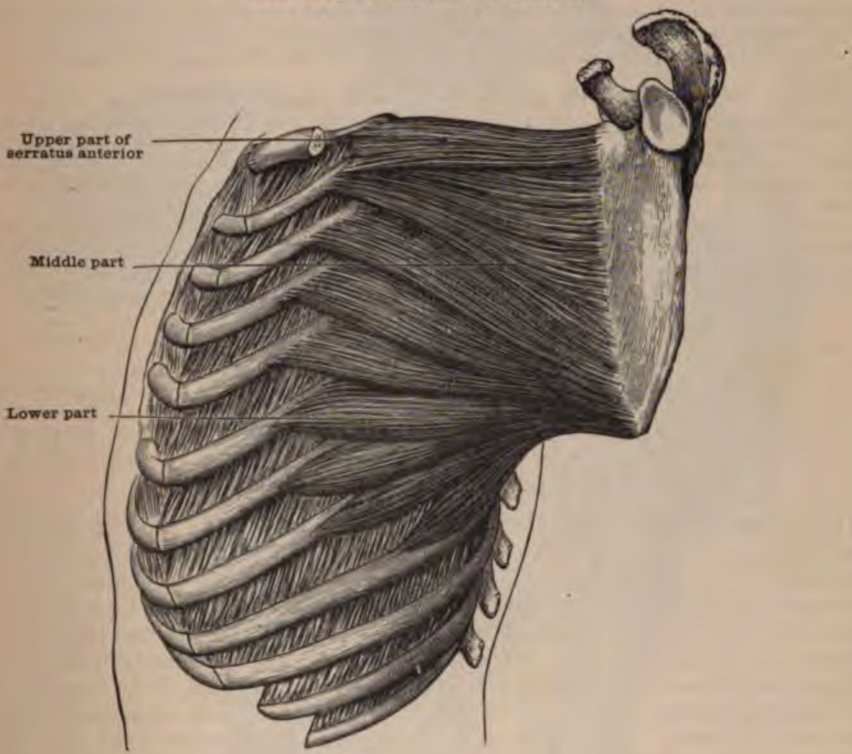
Action.—The two muscles draw the scapula upwards and inwards towards the spine and rotate it so as to depress the shoulder.

Relations.—Over the muscles lies the trapezius. Under them lie the serratus posterior superior and the splenius colli, the longissimus dorsi, the ilio-costalis, and external intercostal muscles. The descending ramus of the transversa colli artery descends on the deep surface. Blood-vessels for the trapezius pass to this muscle between the two rhomboids.

Variations.—There is much variation in the extent of the vertebral attachment. The minor is frequently, the major occasionally, absent. The two rhomboids are frequently fused with one another or may be divided into several distinct fasciculi. Slips may be sent to the latissimus dorsi or the teres major. An accessory slip may pass between the trapezius and splenius muscles to the occipital bone (**occipito-scapularis**). A muscle corresponding to this fasciculus is normally found in many mammals.

The **levator scapulæ** (figs. 316, 349).—*Origin.*—By short tendons from the dorsal tubercles of the transverse processes of the first four cervical vertebræ, between the attachments of the splenius cervicis and scalenus medius muscles. *Structure and Insertion.*—The fibres run in parallel bundles in a dorso-lateral direction downwards to the vertebral border of the scapula opposite the supraspinous fossa. The fibre-bundles are inserted directly into the periosteum. As a rule, the flat fasciculi arising from the different vertebræ are easily separated.

FIG. 317.—SERRATUS ANTERIOR.



Nerve-supply.—By rami from the third, fourth, and fifth cervical nerves. These rami enter the ventral margin of the muscle and extend obliquely across the dorsal surface of the constituent fasciculi about midway between the tendons of origin and insertion. Frequently anastomosing branches pass between the nerves. The lowest fasciculus is usually supplied by branches from the nerve to the rhomboid muscles (dorsal scapular).

Action.—Draws the scapula upwards and tends to rotate it so that the inferior angle approaches the spine. When the scapula is fixed, the muscle serves to bend the neck laterally and slightly to rotate it towards the same side and extend it.

Relations.—Externally the sterno-cleido-mastoid and, in part, the splenius capitis cover it above; the trapezius, below; and the external cervical fascia, its middle portion. Internally lie the splenius cervicis, longissimus cervicis (transversalis cervicis), and serratus posterior superior muscles and the ramus descendens of the transversa colli artery.

Variations.—The number of cervical vertebræ from which the muscle springs varies from two to seven. The most constant are the slips of origin from the first two vertebræ. The muscle may send slips to the temporal or the occipital bone or to the trapezius, the serratus anterior (magnus), serratus posterior superior, and other muscles, or to the clavicle, first or second rib, etc. Often the parts of the muscle running to each vertebra are separated for the whole distance. A bundle of fibres that appears to be a detached slip of the levator scapulæ may run from the first two or from lower cervical vertebræ to the lateral end of the clavicle and to the acromion. This represents the **levator claviculæ** found normally in many vertebrates. According to Le Double, it is innervated by a branch from the cervical branches to the trapezius group.

The **serratus anterior** (magnus) (figs. 317, 349).—*First Part.*—The origin is by two digitations from the first and second ribs and from a fibrous arch uniting these two attachments. The fibre-bundles converge to be inserted on an oval space on the costal surface of the scapula near its medial angle. *Second Part.*—This arises by two or three digitations from the second, third, and sometimes the fourth ribs. The fibre-bundles spread out into a thin sheet which is inserted along the vertebral border of the scapula. *Third Part.*—This, the strongest part of the muscle, arises by digitations from the fourth or fifth to the eighth or ninth ribs. The attachments of the digitations are longest on the upper border of each rib. They interdigitate with the attachments of the external oblique muscle of the abdomen. The fibre-bundles converge to be inserted on the large oval space on the costal surface near the inferior angle of the scapula.

Nerve-supply.—From the proximal portions of the anterior divisions of the fifth, sixth, and seventh cervical nerves branches arise which fuse into the long thoracic nerve. This nerve usually passes laterally through or behind the scalenus medius muscle, courses along the outer surface of the serratus anterior midway between the origin and insertion, and gives rise to numerous twigs to supply the various divisions. The fibres to the upper portion come mainly from the fifth cervical nerve; that to the middle from the fifth and sixth; and that to the lower from the sixth and seventh.

Action.—The muscle holds the scapula against the thorax and draws it forwards and laterally and, by its highly developed inferior portion, rotates the bone so as to raise the point of the shoulder. It is of especial importance in abduction of the arm. It also aids, to a slight degree, in forced inspiration.

Relations.—Superficial to the muscle lie the pectoralis major and minor, the subclavius, subscapularis, and latissimus dorsi muscles, the subclavian and axillary vessels, and the brachial plexus. Between the latissimus dorsi and pectoral muscles it is covered by skin and fascia inferiorly, and superiorly by the fatty areolar tissue of the axillary fossa. Under it lie the external intercostal, serratus posterior superior, and the lower extremity of the scalenus posterior muscles.

Variations.—The digitations may extend to the tenth or only to the seventh rib. The muscle may be continuous with the levator scapulæ as it is in the carnivora, or some of its upper digitations may be wanting. Slips may be continued into neighbouring muscles. Occasionally it is absent.

II. THE MUSCULATURE OF THE UPPER LIMB

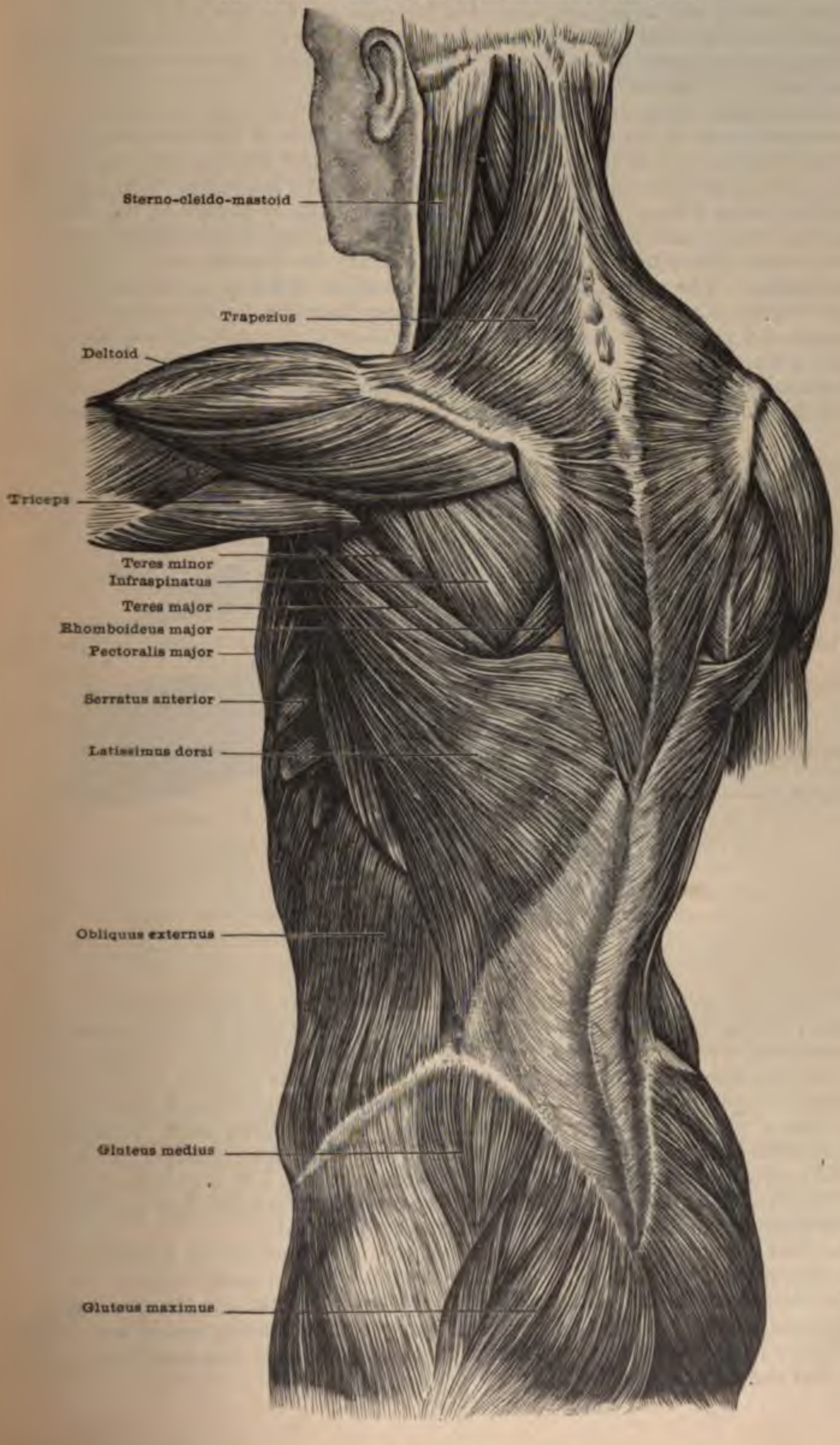
It is chiefly by muscles that the upper limb is attached to the trunk. The sole direct skeletal union is at the sterno-clavicular joint, and in many mammals even this is wanting. Muscles attached to the shoulder girdle and humerus extend, in the neck, to the base of the skull and the hyoid bone, over the surface of the back to the spinal column, over the side of the trunk to the posterior part of the iliac crest, and over the front of the thorax nearly to the abdomen. Of these muscles, those that lie in the region of the neck and on the side and back of the upper part of the trunk represent axial musculature secondarily attached during embryonic development to the appendicular skeleton. They are supplied by direct branches from the anterior divisions of the cervical nerves, supplemented in case of the superficial axio-cingular muscles by the eleventh cranial nerve. These muscles have, therefore, been taken up in the previous section (pp. 337 and 351).

The muscles which extend from the limb skeleton to the front of the thorax and to the lower part of the side and back of the trunk are outgrowths of the intrinsic limb musculature, and are supplied by nerves which arise from the brachial plexus. They will, therefore, be taken up in this section in conjunction with the intrinsic muscles of the limb. These may be conveniently considered according to their relations to successive segments of the appendicular skeleton and in the following order:—

A. Muscles of the shoulder.
B. Muscles of the arm.
C. Muscles of the forearm and hand.

In each segment the muscles are divisible into dorsal and ventral groups, supplied by branches arising respectively from the back and the front of the brachial plexus. The muscles of the shoulder include a dorsal group of muscles which arises from the clavicle, scapula, and the side and back of the lower part of the trunk, and a ventral group, which arises from the front of the thorax. Both groups are supplied by special branches direct from the plexus; the dorsal muscles of the arm and forearm and hand are supplied by the radial (musculo-spiral) nerve; the ventral muscles by the musculo-cutaneous, median, and ulnar nerves.

Fig. 318.—First Layer of Muscles of the Back.


Sterno-cleido-mastoid
Trapezius
Deltoid
Triceps
Teres minor
Infraspinatus
Teres major
Rhomboideus major
Pectoralis major
Serratus anterior
Latissimus dorsi
Obliquus externus
Gluteus medius
Gluteus maximus

A. MUSCULATURE OF THE SHOULDER

1. Dorsal Group

(Figs. 318, 319, 320, 324, 349)

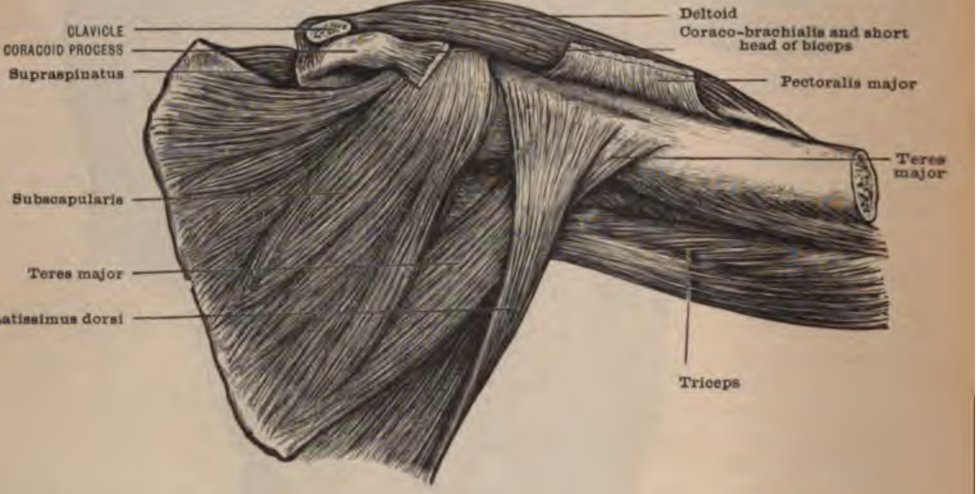
The muscles belonging to this group are the deltoid, the teres minor, the infra- and supraspinatus, the latissimus dorsi, the teres major, and the subscapularis.

The **deltoid** (fig. 318) is a large, shield-shaped muscle which covers the shoulder. It extends from the spine of the scapula, the acromion, and the clavicle to the shaft of the humerus. It serves to abduct the arm.

The teres minor, infra- and supraspinatus form a group of muscles (fig. 324) which arise from the back of the scapula, pass over the capsule of the shoulder-joint, to which their tendons are adherent, and, under cover of the deltoid, are inserted into the top and the dorsal margin of the great tubercle of the humerus. The band-like **teres minor** arises from the upper two-thirds of the axillary border of the scapula, and has the lowest insertion on the tubercle. The triangular **infraspinatus** arises from the whole infraspinous fossa except the axillary border, and is inserted above the teres minor. The pyramidal **supraspinatus** arises under cover of the trapezius from the supraspinous fossa, and has the highest insertion on the tubercle. The teres minor and infraspinatus act as external rotators of the arm, the supraspinatus as an abductor.

The latissimus dorsi, the teres major, and the subscapularis form a group of muscles attached to the lesser tubercle of the humerus and to the crest which extends distally from this on the medial side of the intertubercular (bicipital) groove. The **latissimus dorsi** (figs. 318, 319) is a large, flat, triangular muscle, which arises from an aponeurosis covering the lumbar and the lower half of the thoracic regions of the back and from the posterior part of the iliac crest, and is inserted into the intertubercular (bicipital) groove. The **teres major** (figs. 318, 319) is a thick, ribbon-shaped muscle which arises from the dorsal surface of the inferior angle of the scapula and is inserted behind the latissimus dorsi into the distal two-thirds of the crest of the small tubercle of the humerus. The **subscapularis** (fig. 319) is a thick, triangular muscle which extends from the subscapular fossa to the small tubercle of the humerus. These muscles serve to adduct the arm and rotate it inwards.

Fig. 319.—Front View of the Scapular Muscles.



Near their humeral attachments these two groups of muscles are separated below by the long head of the triceps. The supraspinatus is separated from the subscapularis by the base of the coracoid process and by the intertubercular (bicipital) groove. The tendons of the latissimus dorsi, teres major, and subscapularis are crossed ventrally by the main vessels and nerves of the arm and by the short head of the biceps and the coraco-brachialis.

The supra- and infraspinatus muscles are supplied by the suprascapular nerve. The deltoid and the teres minor are supplied by the axillary (circumflex). The subscapularis, the teres major, and the latissimus dorsi are supplied by subscapular nerves. That to the latissimus dorsi is called the thoraco-dorsal nerve.

The deltoid in many of the mammals and the lower vertebrates is represented by separate scapulo-humeral and cleido-humeral portions. The cleido-mastoid in some mammals is continued into the deltoid. The teres minor, which is innervated by the same nerve, may be looked upon as a derivative of the deltoid, although in man it is anatomically more intimately connected with the infraspinatus. The teres major may be looked upon as a specialised portion of the more primitive latissimus dorsi. The comparative anatomy of the shoulder muscles throughout the vertebrate series is a somewhat intricate subject, owing to the great variations exhibited in the form and attachment of the shoulder girdle.

The muscles of this group show more or less marked resemblances to certain muscles of the lower limb. The deltoid and the teres minor probably represent the tensor fasciæ latæ, the gluteal fascia, and the upper part of the gluteus maximus; the latissimus dorsi and teres major, the lower portion of the gluteus maximus; and the subscapularis, the gluteus medius and minimus, and the piriformis. The subscapular and axillary nerves, which supply the arm muscles mentioned, therefore represent in the main the nerves to the gluteal muscles, and the gluteal branch of the posterior cutaneous nerve of the thigh. The infraspinatus muscle probably represents the iliacus; the supraspinatus possibly the pectineus muscle of the lower limb.

The **fascial** and general relations of the musculature of the shoulder may be followed in the cross-sections shown in figs. 314, 320, 323.

The **tela subcutanea** covering the regions occupied by these muscles is well developed and contains considerable fat. In most regions it is not readily separable into two distinct layers. In the neighbourhood of the shoulder-joint it is adherent to the underlying muscular and the axillary fasciæ. Over the acromion there is a well-marked subcutaneous bursa, **bursa subcutanea acromialis.**

Muscle fasciæ.—The deltoid and latissimus dorsi muscles are throughout the greater part of their extent superficially placed. They are covered by an adherent fascial layer, which, above, is attached to the clavicle and to the spine of the scapula. Ventrally it is continued over and fuses with the fascia covering the pectoralis major, serratus anterior, and external oblique muscles. On the back it extends as a thin sheet between the dorsal margin of the deltoid and the upper margin of the latissimus dorsi, and is continued dorsally into the fascial investment of the rhomboid muscles. The lateral fascial extension of the trapezius becomes fused to the dorsal surface of this sheet.

Towards the armpit the fascial investment of the deltoid and latissimus dorsi muscles is continued into the axillary fascia, and on the back of the arm it is continued into the fascial investment of the triceps.

The supraspinatus muscle lies beneath the trapezius. It is covered by a dense adherent fascial layer which is separated from the trapezius by loose connective tissue.

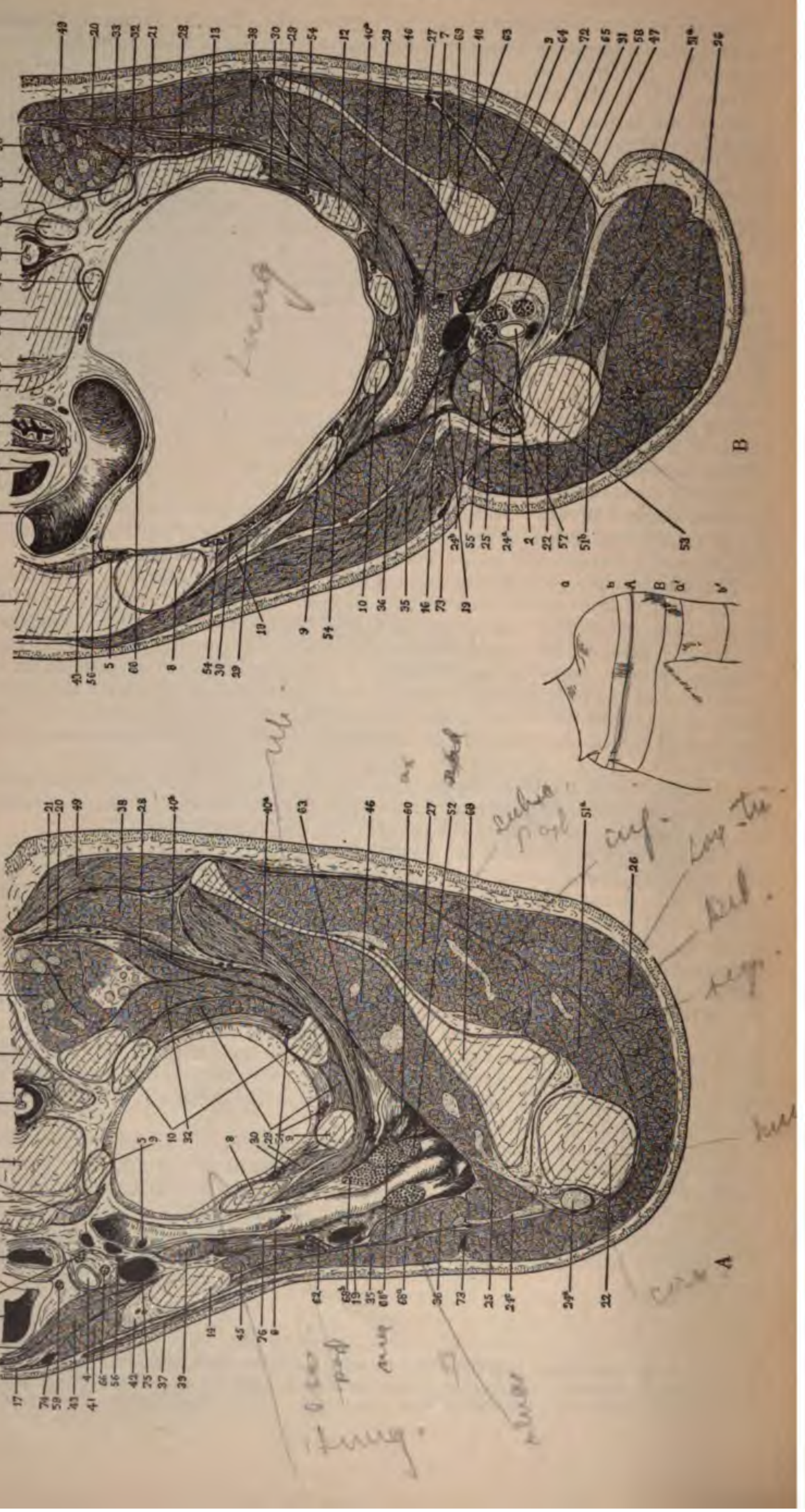
The infraspinatus and the two teres muscles lie beneath the musculo-fascial layer composed of the deltoid, the latissimus dorsi, and the fascial sheet described above, which extends between the two muscles and dorsally is continued into the fascial investment of the rhomboids. Each of the three muscles has a special fascial investment which is bound to the scapula about the area of attachment of the muscle to the bone. Where two of the muscles adjoin, their fasciæ give rise to intermuscular septa. Septa of this nature are found between the infraspinatus and each of the teres muscles, and between the teres minor and the teres major. The intermuscular septum between the infraspinatus and teres minor muscles is often incomplete. Near the spine the fascia covering the deep surface of the deltoid is often fused to that covering the infraspinatus.

The subscapularis muscle is invested by a moderately dense fascia which is bound to the scapula along the periphery of the attachment of the muscle. For a short distance this fascia is fused with the fascial investment of the teres major near the origin of the latter muscle, so that an intermuscular septum is formed. From the ventro-lateral margin of the fascia covering the subscapularis muscle a sheet of fascia is continued below the axillary fascia into the fascia covering the serratus anterior (magnus).

MUSCLES

The **deltoideus** (figs. 318, 319, 321).—*Origin.*—Fleshy from the outer border and upper surface of the acromion and from the ventral border and upper surface of the lateral third of the clavicle, and tendinous from the spine of the scapula. Some fibre-bundles also at times arise

FIG. 320.


A
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Lung

from the deep fascia of the muscle where it overlies, and is fused to the fascia of the infraspinatus muscle near the spine.

Insertion.—Into the deltoid tuberosity of the humerus by a strong tendon arising from numerous tendinous bands within the muscle (fig. 325).

Structure.—In structure the deltoid muscle is complex. Three portions may be recognised:—a clavicular, an acromial, and a spinous. The first and last are composed of long fibre-bundles which take a slightly converging course and are inserted by aponeurotic tendons respectively on the front and back of the V-shaped area of insertion of the muscle. The acromial portion, on the other hand, is multipenniform in composition. Four or five tendinous expansions descend into the muscle from the acromion, and three up into the muscle from the tendon of insertion. From the acromion and from the descending tendinous processes fibre-bundles run to be inserted on the sides of the ascending processes and into the tendons of insertion of the clavicular and spinous portions of the muscle.

Nerve-supply.—The axillary (circumflex) nerve passes across the deep surface of the muscle and gives off rami which enter about midway between the origin and insertion.

Action.—When the whole muscle contracts, the arm is abducted (raised laterally). When the clavicular and acromial parts act, the arm is raised and flexed (brought forwards towards the chest). When the acromial and spinous parts act, the arm is raised and extended (carried towards the back), but in this instance the arm is not brought to a level with the shoulder-joint, but only about 45° from the hanging position. The inferior part of the serratus anterior acts in conjunction with the deltoid in abduction. Abduction is greatest when the arm is rotated outwards. When the arm is fixed, the deltoid tends to carry the inferior angle of the scapula towards the spinal column and away from the thorax.

Relations.—On its ventral border the deltoid is in contact with the pectoralis major muscle. Near the clavicle the cephalic vein and a small artery pass between the two muscles. Its dorsal border is continued into a dense fascial sheet which overlies the infraspinatus muscle. Its tendon of insertion passes between the biceps and triceps muscles. The deltoid overlies the coracoid process and upper extremity of the humerus, the coraco-clavicular and coraco-acromial ligaments, and the insertions of the supraspinatus, infraspinatus, and teres minor muscles, the origins of the biceps and coraco-brachialis, and a part of the long and lateral heads of the triceps. Beneath it run the posterior circumflex artery and axillary (circumflex) nerve.

Variations.—The clavicular portion is frequently separate from the rest of the muscle. The three portions may be distinctly separate—a condition normal in some of the lower mammals. The clavicular and acromial portions have been found missing. The deep portion of the muscle may be separated as a distinct layer and inserted either into the capsule of the joint or into the humerus. Accessory fasciculi may pass into the muscle from the fascia over the infraspinatus and from the vertebral and axillary borders of the scapula. Not infrequently fasciculi are continued into the muscle from the trapezius—a condition normal in animals with ill-developed clavicles. An accessory tendon of insertion may extend to the radial side of the forearm. Bundles of fibres from the axillary border of the scapula have been seen to cross the deep surface of the deltoid and be inserted into the deltoid fascia. The deltoid may be fused with neighbouring muscles, the pectoralis major, trapezius, infraspinatus, brachialis, brachio-radialis.

The **teres minor** (fig. 324).—*Origin.*—From the upper two-thirds of the axillary border of the infraspinous fossa, and from the septa lying between it and the infraspinatus on the one

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FIG. 320, A AND B.—TRANSVERSE SECTIONS THROUGH THE LEFT SHOULDER IN THE REGIONS INDICATED IN THE DIAGRAM.

In the neighbourhood of the brachial plexus in each section some of the adipose and lymphatic tissue has been removed. In section B the fascia covering the apex of the axillary fossa is thus revealed from above. *a* and *b* in the diagram indicate the regions through which pass sections A and B, fig. 314 (p. 346); *a′* and *b′*, the regions through which pass sections A and B, fig. 323 (p. 367).

1. Aorta. 2. Brachial artery. 3. Circumflex scapular artery. 4. Common carotid. 5. Internal mammary artery. 6. Subclavian artery. 7. Lateral thoracic artery. 8. 1st rib. 9. 2nd rib. 10. 3rd rib. 11. 4th rib. 12. 5th rib. 13. 6th rib. 14. Clavicle. 15. Intervertebral disc. 16. Axillary fascia. 17. Cervical fascia (superficial layer). 18. Cervical fascia (middle layer). 19. Coraco-clavicular fascia. 20. Lumbo-dorsal fascia. 21. Fascia of posterior serrati. 22. Humerus. 23. Spinal cord. 24. Biceps—*a*, long head; *b*, short head; *c*, tendon of short head. 25. Coraco-brachialis. 26. Deltoideus. 27. Infraspinatus. 28. Ilio-costalis dorsi (accessorius). 29. Intercostales externi. 30. Intercostales interni. 31. Latissimus dorsi, tendon. 32. Levator costæ. 33. Longissimus dorsi. 34. Longus colli. 35. Pectoralis major. 36. Pectoralis minor. 37. Platysma. 38. Rhomboideus major. 39. Scalenus anterior. 40*a*. Serratus anterior. 40*b*. Serratus posterior superior. 41. Sterno-mastoideus. 42. Cleido-mastoideus, insertion. 43. Sterno-hyoideus. 44. Sterno-thyreoideus. 45. Subclavius. 46. Subscapularis. 47. Teres major. 48. Teres minor. 49. Trapezius. 50. Transverso-spinales. 51. Triceps—*a*, long head; *b*, lateral head. 52. Axillary nerve. 53. Medial antibrachial (internal) cutaneous nerve. 54. *a*–*e*, 1st to 5th intercostal nerves. 55. Median nerve. 56. Phrenic nerve. 57. Musculo-cutaneous nerve. 58. Radial (musculo-spiral) nerve. 59. Recurrent laryngeal nerve. 60. Subscapular nerve. 61. Sympathetic trunk. 62. Anterior thoracic nerve. 63. Long thoracic nerve. 64. Thoraco-dorsal nerve. 65. Ulnar nerve. 66. Vagus nerve. 67. Œsophagus. 68. Brachial plexus—*a*, lateral fasciculus; *b*, medial; *c*, posterior. 69. Scapula. 70. Sternum. 71. Trachea. 72. Brachial veins. 73. Cephalic vein. 74. Anterior jugular vein. 75. Internal jugular vein. 76. Subclavian vein. 77. 1st vertebra. 78. 2nd vertebra. 79. 3rd vertebra. 80. 4th vertebra. 81. 5th vertebra. 82. 6th vertebra.

side and the teres major on the other. The origin is in part fleshy, in part from an aponeurotic band on its ventral surface towards the subscapularis muscle.

Structure and Insertion.—The fibre-bundles from this origin take a slightly converging course towards a tendon of insertion which extends for some distance on the dorsal surface of the muscle The muscle is adherent to the capsule of the joint, and terminates on the inferior of the three facets of the great tubercle of the humerus and the posterior surface of that bone for two or three centimetres below the facet.

Nerve-supply.—From a branch of the axillary (circumflex) nerve which enters the muscle on its lateral margin about midway between its extremities. A 'ganglion' is usually found upon this nerve. A branch from the nerve to the teres major has also been reported.

Action.—It acts conjointly with the infraspinatus to rotate the arm externally.

Relations.—The muscle is in part covered by the deltoid. Ventrally it enters into relations with the long head of the triceps, the teres major, and the subscapularis. Superiorly, the circumflex (dorsal) scapular vessels run between it and the axillary border of the scapula.

Variations.—Aside from its frequent fusion with the infraspinatus, there has also been reported an isolation of a special fasciculus to the subtubercular attachment.

The **infraspinatus** (fig. 324).—*Origin.*—From the vertebral three-fourths of the infraspinous fossa, from the under surface of the spine, from the enveloping fascia and from a thick intermuscular septum between it and the two teres muscles.

Structure and Insertion.—The fibre-bundles converge towards the external angle of the scapula to be attached to a deep-seated tendon which is adherent to the capsule of the joint and is attached to the middle facet of the great tubercle. The fibre-bundles arising from the inferior surface of the spine and the fascia near this form a distinct fasciculus which descends on and covers the tendon of insertion.

Nerve-supply.—From the suprascapular nerve, which passes beneath the supraspinatus muscle and enters the deep surface of the infraspinatus in the lateral part of the middle third of its upper margin. From here rami spread out towards the vertebral border of the muscle and towards the humeral insertion.

Action.—This muscle is the chief external rotator of the arm, a movement that can be carried through 90°.

Relations.—The deltoid and trapezius, and sometimes the latissimus dorsi muscles, cover a portion of the dorsal surface. Over most of it extends the complex fascia described above. Laterally it adjoins the teres minor and major muscles. Under the muscle lie the transverse (suprascapular) and circumflex (dorsal) scapular vessels.

Variations.—These are rare, aside from a greater or less independence of the bundles arising from the spine and a greater or less complete fusion with the teres minor. A fasciculus has been seen extending to the muscle from the deltoid.

The **supraspinatus** (fig. 324).—*Origin.*—Fleshy from the inner two-thirds of the supraspinous fossa and from the deep surface of the enveloping fascia near the vertebral end.

Structure and Insertion.—The fibre-bundles converge upon a deep-seated tendon nearly to its attachment into the highest of the three facets on the great tubercle of the humerus.

Nerve-supply.—A branch from the suprascapular nerve enters the middle third of the deep surface of the muscle.

Action.—It aids the deltoid in raising the shoulder. According to Duchenne, it is also a weak internal rotator. It aids in keeping the head of the humerus in place during abduction of the arm.

Relations.—The muscle is covered by the trapezius, the acromion, and the coraco-acromial ligament. Beyond the base of the spine of the scapula it comes into contact with the infraspinatus muscle. Beneath the muscle pass the suprascapular nerve and transverse scapular (suprascapular) vessels.

Variations.—The muscle shows slight variations. Its tendon may be fused with that of the infraspinatus. Its belly may be reinforced by fibre-bundles from the coraco-acromial ligament.

L. D.

The **latissimus dorsi** (figs. 318, 319, 348, 349).—*Origin.*—(1) From an aponeurosis attached to the spines and interspinous ligaments of the five or six last thoracic and the upper lumbar vertebræ, to the lumbo-dorsal fascia, and to the posterior third of the external lip of the crest of the ilium; (2) from the external surface and upper margin of the last three or four ribs by muscular slips which interdigitate with those of the external oblique.

Structure and Insertion.—From this extensive area of the origin fibre-bundles converge towards the tendon of insertion. In the region of the dorsal wall of the axillary fossa the muscle is concentrated into a thick, ribbon-like band which winds about the teres major and passes to the ventral surface of that muscle. As this takes place the fibre-bundles become applied to each surface of a flat tendon, which, after emerging from the muscle, is six to eight cm. long and three to five cm. broad, and is inserted into the ventral side of the crest of the lesser tubercle of the humerus or into the depth of the intertubercular (bicipital) groove immediately ventral to the tendon of the teres major. With this it is more or less closely bound, although between the tendons there lies a serous bursa. Frequently a tendon slip passes from the inferior margin of the tendon to the tendon on the posterior surface of the long head of the triceps or into the brachial fascia (see DORSO-EPITROCHLEARIS MUSCLE, p. 370).

Like the teres major, with which it is closely associated, the latissimus dorsi muscle undergoes a torsion between its origin and its insertion, so that the dorsal surface of the muscle is continued into the ventral surface of the tendon and the most cranially situated of the fibre-bundles are most distally attached to the humerus, and *vice versâ*. The muscle either directly or through its fascial extension is often adherent to the inferior angle of the scapula.

Nerve-supply.—From the thoraco-dorsal (long subscapular) nerve. This nerve, which may arise in conjunction with the axillary nerve, passes to the deep surface of the muscle in the lower part of the axillà, and here gives rise to rami which diverge as the muscle expands towards its tendons of origin. Though soon embedded in the muscle substance, two main branches may be followed for a considerable distance near the deep surface of the muscle. One usually extends near the lateral, the other near the superior, border of the muscle, and from these large rami pass into the intervening area. Branches of the thoraco-dorsal artery and vein accompany the nerve.

Action.—With the trunk fixed, the latissimus dorsi draws the raised arm down and backwards and rotates it inwards (swimming movement). When the arm is hanging by the side, the action of the muscle is on the scapula. The upper third of the muscle draws the scapula towards the spine, the inferior two-thirds depress the shoulder. When the humerus is fixed, the latissimus serves to lift the trunk and pelvis forwards, as in climbing. It also aids in forced inspiration through its costal attachments.

Relations.—The trapezius covers a small portion of the muscle in the mid-thoracic region of the back. Over a large area it is subcutaneous, and its fascial investment is adherent to the skin. As it winds about the teres major its tendon comes to lie behind the coraco-brachialis muscle. The main nerves and vessels of the arm here pass across its ventral surface. The muscle covers in part the rhomboideus major, the infraspinatus, teres major, serratus posterior inferior, the lower ribs, the external intercostal muscles, the dorsal border of the external and internal oblique muscles, and the lower dorsal part of the serratus anterior (magnus).

Variations.—It may show considerable variation in the extent of its fleshy portion and in the attachment of its aponeurosis to the vertebral column, crest of the ilium, the ribs, and the scapula. Its origin may be merely from the ribs. It may be divided into separate fasciculi. Frequently a fasciculus arises from the inferior angle of the scapula. The muscle is often intimately united to the teres major. For an account of the muscular slip which extends from the latissimus dorsi across the axilla to the tendon of the pectoralis major near the intertubercular (bicipital) groove see the latter muscle (p. 366); and for the slip continued from the tendon of the latissimus dorsi to the olecranon see the TRICEPS MUSCLE (p. 370).

The **teres major** (fig. 319, 349).—*Origin.*—Directly from the dorsal surface of the inferior angle of the scapula and from the septa which lie between this muscle and the subscapularis, teres minor, and infraspinatus muscles.

Insertion.—For about five or six cm. from the lower border of the small tubercle of the humerus, along the medial lip of the intertubercular (bicipital) groove. Proximally the fibre-bundles are attached directly to the tubercle; more distally the attachment is by means of a flat tendon which extends for some distance on the dorsal surface of the muscle.

Structure.—The nearly parallel fibre-bundles pass upwards in a spiral direction so that the muscle undergoes a torsion on its axis. The fibre-bundles which have the highest attachment to the scapula have the lowest humeral attachment, and *vice versâ.*

Nerve-supply.—By a branch of the lower subscapular nerve which enters the muscle near the middle of its anterior border.

Action.—It aids the latissimus dorsi in adducting the arm, and in some positions of the arm acts as an internal rotator.

Relations.—Dorsally the muscle is covered by the latissimus dorsi and the fascia which extends from this muscle to the deltoid and rhomboid muscles. It is also crossed by the long head of the triceps. Its lower border and ventral surface are largely covered by the latissimus dorsi and its tendon. Its upper border helps to bound a triangular space the other sides of which are the borders of the scapula and the humerus. In front lies the subscapularis, and behind, the teres minor. Across this space passes the long head of the triceps. Lateral to this head lie the humeral circumflex vessels and axillary (circumflex) nerve; and medial, the circumflex (dorsal) scapular artery.

Variations.—The teres major may be connected with the latissimus dorsi by a fasciculus, or it may be fused with that muscle or its tendon. Slips have also been seen extending to the triceps and into the fascia of the arm. The muscle is rarely absent.

The **subscapularis** (fig. 319, 349).—*Origin.*—The fibre-bundles spring—(1) directly and by means of tendinous bands from the costal surface of the scapula, except near the neck and at the upper and lower angles; and (2) from intermuscular septa between it and the teres major and teres minor muscles.

Insertion.—The tendon of insertion as it passes over the capsule of the joint is intimately bound to this. It is inserted into the small tubercle of the humerus and into the shaft immediately below this.

Structure.—The fibre-bundles arising from the tendinous bands attached to the bone converge upon several tendinous laminæ which extend into the muscle from the tendon of insertion, thus forming small penniform fasciculi. The fibre-bundles arising directly from the bone converge towards the extremities of the tendinous laminæ, thus forming triangular bundles interdigitating with the penniform fasciculi. The fasciculus which arises highest on the axillary border goes directly to the humerus.

Nerve-supply.—By two or three subscapular branches from the back of the brachial plexus. One or more of these may arise in association with the axillary (circumflex) nerve. From the main nerves rami spread out to enter the ventral surface of the muscle near the junction of the outer and middle thirds.

Action.—It is the chief internal rotator of the arm. It strengthens the shoulder-joint by drawing the humerus against the glenoid cavity. It is a weak adductor of the arm.

Relations.—Ventrally it forms the greater part of the posterior wall of the axillary fossa, and enters into relation with the serratus anterior (magnus) and the combined tendon of the coraco-brachialis and biceps. On it lie the axillary vessels, the brachial plexus, and numerous lymph-vessels and glands. At its lateral border lie the teres major, the humeral circumflex vessels, axillary (circumflex) nerve, and circumflex (dorsal) scapular vessels. Behind it lie the long head of the triceps and the teres minor muscle.

Variations.—It may be divided into several distinct segments. A fasciculus may be sent to the tendon of the latissimus dorsi and another to the brachial fascia. The **subscapularis minor** arises from the axillary border of the scapula and is inserted into the articular capsule (capsular ligament) of the shoulder-joint or into the crest of the lesser tubercle of the humerus.

BURSÆ

B. subacromialis.—A large bursa, nearly constantly found, between the acromion and coraco-acromial ligament and the insertion of the supraspinatus muscle and capsule of the joint.

B. subdeltoidea.—Nearly constant between the deltoid and the great tubercle of the humerus. This is often fused with the bursa subacromialis.

B. m. subscapularis.—Between the glenoid border of the scapula and the subscapularis muscle. Communicates with the joint cavity. A small portion of this bursa may be isolated adjacent to the base of the coracoid process (b. subcoracoidea).

B. m. infraspinati.—Between the tendon of the infraspinatus and the capsule of the joint or the great tubercle.

B. m. latissimi dorsi.—Constant between the tendons of the latissimus dorsi and the teres major.

B. m. teretis majoris.—Under the insertion of the tendon of the teres major muscle.

VENTRAL GROUP

(Figs. 320, 321, 322, 349)

The muscles belonging to this group are the pectoralis major, pectoralis minor, and the subclavius. Of these, the largest and most superficial is the triangular **pectoralis major** (fig. 321), which arises from the front of the thorax and the medial two-thirds of the clavicle and is inserted into the crest of the greater tubercle of the humerus (pectoral ridge). Its lateral margin adjoins the ventral margin of the deltoid. Beneath this muscle the much smaller triangular **pectoralis minor** (fig. 349) extends from near the ends of the second, third, fourth, and fifth ribs to the tip of the coracoid process, while the small **subclavius** (fig. 322) extends from the first rib upwards and lateralwards to the clavicle.

The pectoral muscles and the subclavius play a part in forced inspiration. The pectoralis major also serves to adduct and flex the arm and rotate it inwards.

Of the muscles included in this group, the two pectoral muscles are morphologically the most closely related. They receive a nerve-supply from the same set of nerves, the anterior thoracic. With them the subclavius, which has a separate nerve of its own, is closely associated. Corresponding musculature, although variously modified in different forms, is found throughout the vertebrate series. In the lower forms it seems to be differentiated directly from the segmental trunk musculature and secondarily attached to the shoulder girdle, like the axio-cingular musculature. In man, however, the muscle mass from which these muscles arise is at all times in intimate union with the skeleton of the upper limb, and the nerves which supply it are in much more intimate union with the brachial plexus than are those of the axio-cingular muscles. For these reasons the three muscles are classed with the intrinsic muscles of the arm. They have no certain representatives in the lower limb, although the clavicular portion of the pectoralis major is considered by some to represent certain adductor muscles of the thigh. Possibly they correspond in their embryonic origin with the obturator internus group of the lower limb.

In many of the mammals a subcutaneous muscle arises from the pectoral muscle mass and extends over the axilla and the trunk. In man this musculature is frequently represented by abnormal slips of muscles, of which the 'axillary arch' and possibly the 'sternalis' are representatives. A list of some of the abnormal muscles which are innervated from the anterior thoracic nerves and are evidently derivatives of the pectoral muscle mass is given at the end of this section.

In the **tela subcutanea** of the pectoral region the mammary gland is embedded between two layers which ensheath the gland and are connected by dense fibre-bands. To a greater or less extent the platysma extends into the tela of this region from above the clavicle.

Muscle fasciæ.—The pectoralis major is invested with a thin, adherent membrane, **fascia pectoralis,** attached to the clavicle and the sternum and continued into the fascial investment of the external oblique, the serratus anterior (magnus), and the deltoid muscles, and into the axillary fascia. More important is the **coraco-clavicular (costo-coracoid) fascia.** This arises from two fascial sheets which invest the subclavius muscle and are attached to the clavicle. From the inferior margin of this muscle the membrane is continued to the superior margin of the pectoralis minor. Between the coracoid process and the first costal cartilage it is strengthened to form the **costo-coracoid ligament.** Between this and the pector-

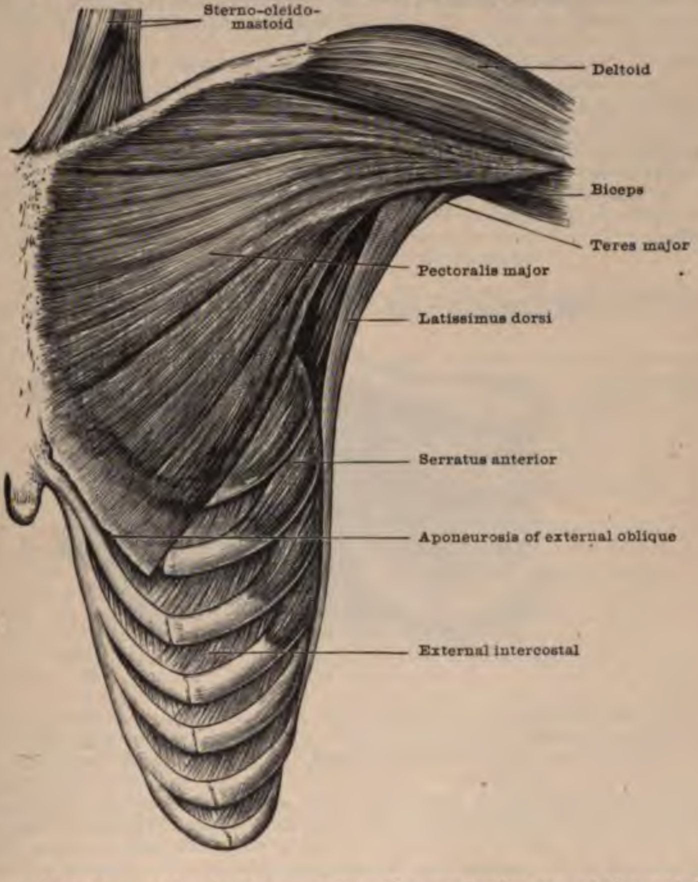
pec. maj
pec. minor
subclavius

alis minor it is thin. At the superior margin of this muscle it again divides to form two adherent fascial sheets, which, at the axillary margin of the muscle, once more unite to form a firm membrane continued into the fascial investment of the coraco-brachialis and short head of the biceps and into the axillary fascia. Above, dorsally, the membrane is adherent to the sheath of the axillary vessels and nerves.

Axillary fascia (fig. 320).—The arm-pit, or axillary fossa, is a pyramidal space bounded by the pectoralis major and minor and coraco-brachialis muscles in front; by the latissimus dorsi, teres major, and subscapularis muscles behind; by the subscapularis muscle towards the joint; and by the serratus anterior (magnus) towards the thoracic wall. In the groove between the coraco-brachialis and the subscapularis and tendons of the latissimus dorsi and teres major muscles run the main nerves and vessels of the arm. These are surrounded by a considerable amount of connective tissue in which numerous blood- and lymph-vessels, lymph-nodes, nerves, and masses of fat are embedded.

pectoralis major
deltoid

FIG. 321.—THE PECTORALIS MAJOR AND DELTOID.



Over this connective tissue the fascia covering the musculature of the neighbouring portion of the shoulder and thorax is continued into the fascia covering the musculature of the inner side of the arm. Thus the fascia covering the pectoralis minor, the coraco-clavicular fascia, strengthened by a reflection of the fascial investment of the pectoralis major and deltoid muscles, is continued across the ventral margin of the arm-pit into the fascia which covers the coraco-brachialis and biceps muscles in the arm. Similarly, dorsally, the fascia covering the latissimus dorsi and teres major is continued over the arm-pit into that covering the long head of the triceps in the arm. The ventral is connected with the dorsal fascia by a thin membrane which is adherent to the connective tissue filling the axillary space and to the subcutaneous tissue. On the trunk this membrane, the **fascia axillaris,** becomes fused below the axillary fossa with the fascia of the serratus anterior (magnus).

In the arm it becomes fused with the fascia over the biceps muscle. Owing to its adherence to the skin and the connective tissue of the axillary fossa, investigators have dissected out and figured the axillary fascia in different ways.

MUSCLES

The **pectoralis major** (fig. 321).—*Origin.*—(1) From the medial two-thirds of the clavicle; (2) from the side and front of the sternum as far as the lower end of the xiphoid process; (3) from the front of the cartilages of the second to the seventh ribs; and (4) from the aponeurosis of the external oblique where this extends over the rectus abdominis muscle. The costal origin may in part take place from the osseous extremities of the sixth and seventh ribs.

Insertion.—Crest of the greater tubercle (outer lip of the bicipital groove) of the humerus from the tubercle to the insertion of the deltoid (fig. 326). Some of the tendon fibres are also continued into the tendon of the deltoid and adjacent fibrous septa and into a membranous process which extends towards the capsule of the joint over the long head of the biceps.

Structure.—The muscle is divisible into a series of overlapping layers spread out like a fan. Of these, the clavicular portion forms the most cranial and superficial layer, and the portion of the muscle springing from the aponeurosis of the external oblique, the most caudal and deepest layer. This last layer has a special tendon, while the other layers are inserted into a combined tendon lying ventral to this. The two tendons are continuous at their distal margins. (W. H. Lewis.)

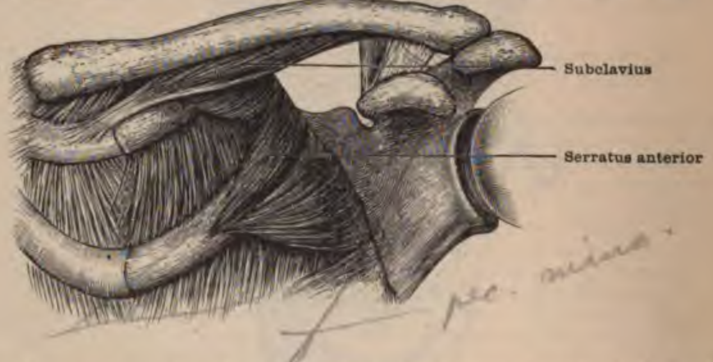
Nerve-supply.—From the external and internal anterior thoracic nerves, branches of which enter the sterno-costal portion of the muscle about midway between the tendons of origin and insertion, and the clavicular portion in the proximal third.

Action.—With the thorax fixed, the muscle adducts and flexes the arm and rotates it inwards. The clavicular portion draws the arm forwards, upwards, and inwards; the sterno-costal portion draws the arm downwards, inwards, and forwards. When the arm is pendent, the clavicular portion elevates, the sternal depresses, the shoulder. With the arm fixed, the muscle draws the chest upwards towards it. It is of value in forced inspiration.

Relations.—It lies over the coracoid process, the subclavius, pectoralis minor, intercostal, and serratus anterior (magnus) muscles, the coraco-clavicular (costo-coracoid) fascia, and the thoraco-acromial vessels. It forms the main part of the ventral wall of the axillary fossa, and latterly it enters into relation with the deltoid, biceps, and coraco-brachialis muscles.

FIG. 322.—THE SUBCLAVIUS AND THE UPPER PORTION OF THE SERRATUS ANTERIOR.

Good Diagram.



Variations.—In considering variations the muscle may be looked upon as composed of four portions—a clavicular, a sternal, a costal, and an abdominal, the last being that portion which arises from the aponeurosis of the external oblique. These portions vary in the extent of their attachments and in the degree of separation which they present. The abdominal portion may extend to the umbilicus. Huntington considers this portion a derivative of the pannicular muscle of the lower mammals. On the sternum the muscles of the two sides may decussate across the middle line. The sterno-costal portions of the muscle are more frequently deficient or missing than the clavicular, but in rare cases the entire muscle is absent. The clavicular portion of the muscle may be fused with the deltoid. The sterno-costal may extend laterally to the latissimus dorsi. There may be an intimate fusion of the abdominal portion with the rectus abdominis or the external oblique. Sometimes a slip may run from the pectoralis major to the biceps, the pectoralis minor, coracoid process, capsule of the joint, or brachial fascia.

The **pectoralis minor** (fig. 349).—*Origin.*—By aponeurotic slips from the second, third, fourth, and fifth ribs near the costal cartilages.

Structure and Insertion.—The fibre-bundles converge upwards and outwards to a flattened tendon which is attached to the medial border and upper surface of the coracoid process of the scapula.

Nerve-supply.—From the internal anterior thoracic nerve which enters the upper part of the middle third of the deep surface by several branches. Some of the branches extend through to the pectoralis major.

Action.—When the thorax is fixed, the pectoralis minor pulls the scapula forwards, the lateral angle of the bone downwards, and the inferior angle dorsalwards and upwards. When the scapula is fixed, the muscle aids in forced inspiration.

Relations.—It is covered by the pectoralis major. Near its insertion the fibrous investment of the chief nerves and vessels of the arm is adherent to its enveloping fascia.

Variations.—The origin may extend to the sixth rib or may be reduced to one or two ribs. In the primates below man the insertion of the muscle takes place normally into the humerus. In man its insertion may be continued (in more than 15 per cent. of bodies—Wood) over the coracoid process to the coraco-acromial or coraco-humeral ligaments, to the tendon of the subscapularis muscle, or to the great tubercle of the humerus. It may be divided into two superimposed fasciculi. Fasciculi may extend from the muscle to the subclavius or the pectoralis major.

The **subclavius** (fig. 322).—*Origin.*—From a flat tendon attached to the first rib and its cartilage near their junction.

Structure and Insertion.—The fibre-bundles arise in a penniform manner from the tendon of origin which extends for some distance along the lower border of the muscle. They are inserted in a groove which lies on the lower surface of the clavicle between the costal tuberosity and the coracoid tuberosity. The medial fibre-bundles are inserted directly, the lateral by a strong tendon.

Nerve-supply.—By a branch which arises usually from the fifth or fifth and sixth cervical nerves and enters the middle of the back part of the muscle.

Action.—When the first rib is fixed, the subclavius depresses the clavicle and the point of the shoulder. When the clavicle is fixed, the muscle aids in forced inspiration. It also serves to keep the clavicle against the sternum.

Relations.—It is concealed by the clavicle and pectoralis major muscle. Behind it lie the subclavian vessels and the brachial plexus.

Variations.—It may be replaced by a ligament or by a pectoralis minimus muscle (see below). It may be doubled or may be inserted into the coracoid process, coraco-acromial ligament, the acromion, or the humerus.

Abnormal Muscles of the Pectoral Group

The following muscles are usually innervated by the anterior thoracic nerves and are probably generally abnormal derivatives of the pectoral mass. Frequently they represent muscles normally found in lower mammals.

The **sternalis.**—A flat muscle somewhat frequently seen on the surface of the pectoralis major, usually nearly parallel to the sternum. It arises from the sheath of the rectus and from some of the costal cartilages (third to seventh) and terminates on the sterno-cleido-mastoid, on the sternum, or on the fascia covering the pectoralis major. When present on both sides, the two muscles may be fused across the sternum. This muscle is found in 4 per cent. of normal individuals and 48 per cent. of anencephalic monsters. (Eisler.) Rarely corresponding muscle slips have been found innervated by the intercostal nerves. These probably represent remains of a thoracic 'rectus' muscle.

The **pectoro-dorsalis (axillary arch)**.—This muscle in its most complete form extends from the tendon of the pectoralis major over the axillary fossa to the tendon of the latissimus dorsi, to the fascia covering the latissimus dorsi, to the teres major or even more distally. It may, however, be more or less fused with either of the last two muscles mentioned, and it presents a great variety of forms. It may extend from the latissimus dorsi to the brachial fascia over the coraco-brachialis or biceps, to the long tendon of the biceps, to the axillary fascia, to the axillary margin of the pectoralis minor, or to the coracoid process, etc. It is found in about 7 per cent. of bodies. (Le Double.) When supplied from the anterior thoracic nerves, it probably represents a portion of the thoraco-humeral subcutaneous (pannicular) muscle of the lower primates. It is also sometimes supplied by the medial brachial cutaneous or the intercostobrachial (humeral) nerve and frequently is partly or wholly supplied by the thoraco-dorsal (long subscapular) nerve. The part of the muscle supplied by the thoraco-dorsal nerve is probably derived from the latissimus dorsi musculature.

The **costo-coracoideus.**—A muscular slip which arises from one or more ribs or from the aponeurosis of the external oblique between the pectoralis major and latissimus dorsi muscles, and is inserted in the coracoid process.

The **chondro-epitrochlearis.**—This is a slip which springs from one or two rib cartilages or from the thoraco-abdominal fascia beneath the pectoralis major, or from its lower border or tendon, and extends on the inner side of the arm to the intertubercular (bicipital) groove, the brachial fascia, the intermuscular septum, or the medial epicondyle. It is found in 12 to 20 per cent. of bodies (Le Double), and occurs normally in many of the lower mammals.

The **sterno-chondro-scapularis.**—From the cartilage of the first rib and sternum to the coracoid process. It is present in about 7 per cent. of instances. (Krause.)

The **sterno-clavicularis.**—From the sternum to the clavicle between the pectoralis major and the coraco-clavicular (costo-coracoid) fascia. Found by Hyrtl in 6 out of 83 bodies.

The **scapulo-clavicularis.**—From the coracoid process of the scapula to the outer third of the clavicle.

BURSÆ

B. m. pectoralis majoris.—Between the tendon of insertion of the pectoralis major and the long head of the biceps. Frequent.

B. MUSCULATURE OF THE ARM

(Figs. 318, 319, 323, 325, 326, 328, 329, 331, 333)

The muscles included in this section are the triceps and anconeus, coraco-brachialis, biceps, and brachialis. The *triceps* and *anconeus* (fig. 324) constitute a mass of musculature extending along the back of the arm from the scapula and humerus to the olecranon of the ulna. The *coraco-brachialis, biceps*, and *brachialis* (figs. 325, 326) constitute a similar mass of musculature extending along the front of the arm from the scapula and the humerus to the humerus, and to the radius and ulna near the elbow. In the upper half of the arm the two groups are separated on the lateral side of the arm by the deltoid, pectoralis major, teres minor, supra- and infraspinatus muscles, and by the great tubercle of the humerus. On the medial side they are separated by the chief nerves and blood-vessels of the arm and by the tendons of the latissimus dorsi, teres major, and subscapularis muscles. In the distal half of the arm they are separated medially by the medial intermuscular septum (described below) and by the medial epicondyle and the pronator-flexor group of muscles of the forearm. On the lateral side of the arm they are separated by the lateral intermuscular septum, by the lateral epicondyle, and by the brachio-radialis and the extensor muscles of the forearm which take origin from the lateral epicondyle.

The **fasciæ** and the general relations of the muscles of the arm are shown in the cross-sections in fig. 323.

The **tela subcutanea** of the arm is fairly well developed and contains a considerable

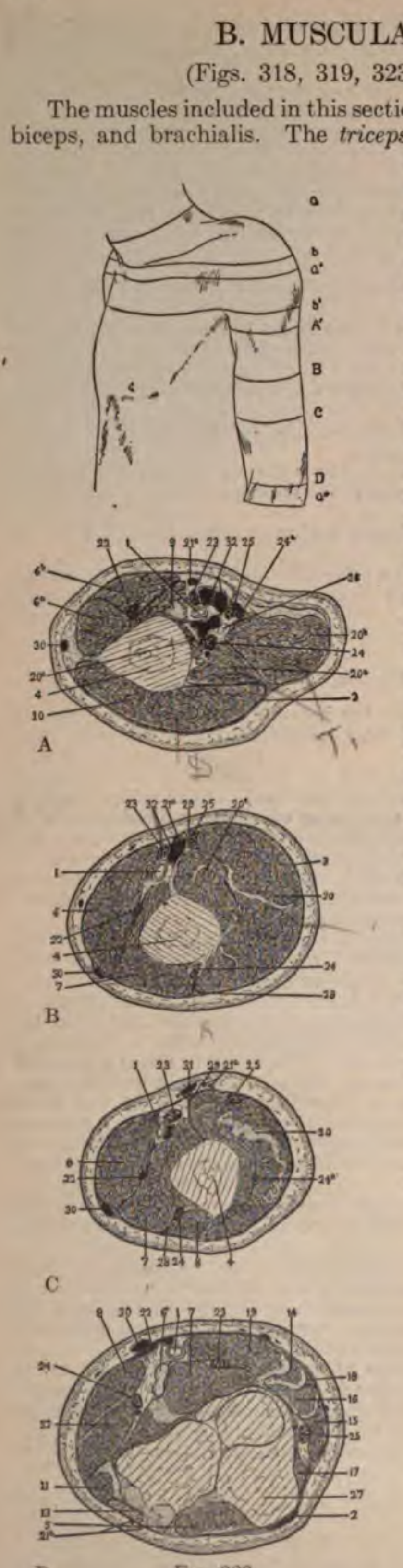


FIG. 323.

FIG. 323, A–D.—TRANSVERSE SECTIONS THROUGH THE LEFT ARM IN THE REGIONS SHOWN IN THE DIAGRAM.

a and *b* in the diagram indicate the regions through which pass sections A and B, fig. 314 (p. 346); *a'* and *b'*, the regions through which pass sections A and B, fig. 320 (p. 358); and *a''* the region through which passes section A, fig. 327 (p. 375).

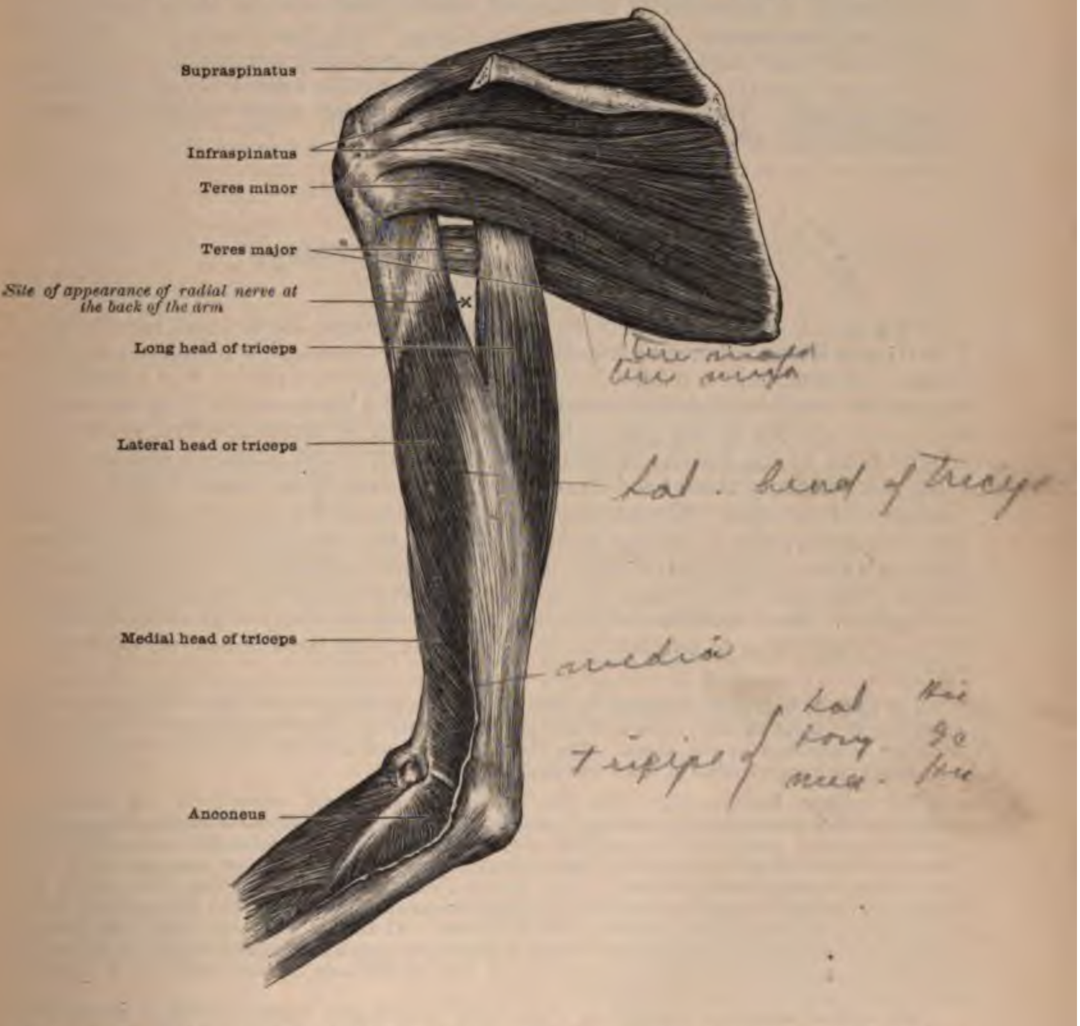
1. Brachial artery. 2. Bursa subcutanea olecrani. 3. Brachial fascia. 4. Humerus. 5. Anconeus. 6. Biceps—*a*, long head; *b*, short head; *c*, tendon of insertion. 7. Brachialis. 8. Brachio-radialis. 9. Coraco-brachialis. 10. Deltoideus. 11. Extensor carpi radialis brevis. 12. Extensor carpi radialis longus. 13. Extensor digitorum communis. 14. Flexor carpi radialis. 15. Flexor carpi ulnaris. 16. Flexor digitorum sublimis. 17. Flexor digitorum profundus. 18. Palmaris longus. 19. Pronator teres. 20. Triceps—*a*, lateral head; *b*, long head; *c*, medial head. 21*a*. Medial antibrachial (internal) cutaneous nerve. 21*b*. Dorsal antibrachial cutaneous nerve. 22. Musculo-cutaneous nerve. 23. Median nerve. 24. Radial nerve—*a*, muscular branch. 25. Ulnar nerve. 26. Lymphatic gland. 27. Olecranon. 28. Lateral intermuscular septum. 29. Medial intermuscular septum. 30. Cephalic vein. 31. Basilic vein. 32. Brachial veins.

amount of fat, especially near the shoulder. It is but loosely bound to the muscle fascia, except near the insertion of the deltoid, where the union may be more intimate.

Bursæ.—B. subcutanea epicondyli lateralis.—Between the lateral epicondyle and the skin. Rare. **B. subcutanea epicondyli medialis.**—Between the medial epicondyle and the skin. Inconstant. **B. subcutanea olecrani.**—Between the olecranon process of the ulna and the skin. Nearly constant.

The **brachial fascia** forms a cylindrical sheath about the muscles of the arm. It contains circular and longitudinal fibres, the former being the better developed. The fascia is strong over the dorsal muscles, especially near the two epicondyles of the humerus. Proximally the fascia of the arm is continued into the axillary fascia and into the fascial investment of the pectoralis major, deltoid, and latissimus dorsi muscles; distally it is continued into the fascial investment of the forearm. It is intimately bound to the epicondyles and to the dorsal surface of the olecranon. It is separated by loose areolar tissue from the bellies of the muscles which it covers. From the tendons of the deltoid, pectoralis major, teres major, and latissimus dorsi muscles, however, fibrous bundles are continued into the brachial fascia. There are a number of orifices in the fascia for the passage of nerves and blood-vessels. Of these, the largest is that for the basilic vein and two or three large branches of the medial antibrachial (internal) cutaneous nerve. This lies on the ulnar margin of the

FIG. 324.—DORSAL VIEW OF THE SCAPULAR MUSCLES AND TRICEPS.


Supraspinatus
Infraspinatus
Teres minor
Teres major
Site of appearance of radial nerve at the back of the arm
Long head of triceps
Lateral head or triceps
Medial head of triceps
Anconeus
tere major
tere minor
Lat. head of triceps
media
Triceps { Lat
Long
Med.

arm in the lower third. On the radial margin lie the cephalic vein in a double fold of the fascia, orifices for branches of the musculo-cutaneous nerve, and more dorsally orifices for branches of the radial. From the fascia septa descend between the muscles which it invests. Of these septa, the most important are the medial and lateral intermuscular septa, which serve to separate the dorsal group of muscles from the ventral in the distal half of the arm. The **medial intermuscular septum** is the stronger. It is attached to the medial epicondyle and to the medial margin of the humerus proximal to this. It is continued proximally into the tendon of insertion of the coraco-brachialis and the investing fascia of this muscle. Into it longitudinal bundles of fibres descend from the tendon. It serves to separate the brachialis and pronator teres muscles from the medial head of the triceps. The **lateral intermuscular septum** is attached to the lateral epicondyle and to the lateral margin of the humerus. It is continued proximally into the dorsal surface of the tendon of insertion of the deltoid muscle, and into the septa between the deltoid and the triceps. It separates the triceps from the brachialis in the third quarter of the arm and from the brachio-radialis and extensor carpi radialis longus in the distal quarter. The median nerve and brachial vessels lie in front of the medial septum. The ulnar nerve and the superior ulnar collateral (inferior profunda) artery are bound to its dorsal surface.

MUSCLES

1. Dorsal or Extensor Group

(Fig. 324)

Two muscles are included in this group, the triceps brachii and the anconeus. The **triceps** is a complex muscle in which proximally three heads, a long or scapular, a lateral humeral, and a medial humeral, may be distinguished. The long head is attached to the infraglenoid tuberosity of the scapula, the lateral head to the humerus above and laterally to the groove for the radial nerve (musculo-spiral groove), the medial head to the lower half and medial margin of the posterior surface of the humerus. Distally these heads fuse and are attached by a common tendon to the olecranon of the ulna. The **anconeus** lies chiefly in the forearm, but physiologically and morphologically it belongs with the triceps, and hence is described in connection with the muscles of the arm. It is a triangular muscle, which arises from the lateral epicondyle and is inserted into the olecranon and adjacent part of the shaft of the ulna. Both muscles are supplied by branches of the radial (musculo-spiral) nerve. They serve to extend the forearm. The long head is also an adductor of the arm.

The triceps, variously modified, is found in the amphibia and all higher vertebrates. The anconeus is found in the prosimians and all higher forms. The triceps muscle is homologous with the quadriceps of the thigh. The long head is equivalent to the rectus femoris. The anconeus is not represented in the lower limb.

The **triceps brachii** (figs. 318, 319, 324).—The *long head arises* from the infraglenoid tuberosity of the scapula by a strong, broad tendon, some of the fibres of which are connected with the inferior portion of the capsule of the shoulder-joint. The tendon soon divides into two lamellæ, which extend distally, one a short distance on the deep surface, the other much farther on the superficial surface of this head. The parallel fibre-bundles which arise from these lamellæ form a thick muscle-band which twists upon itself so that the ventral surface at the origin becomes dorso-medial at the insertion. At the insertion the long head becomes applied to an aponeurosis which extends upwards from the main tendon of insertion of the triceps. The fibre-bundles extend for some distance on the medial side of this tendon and terminate about three-fourths of the way down the arm.

The **lateral head** has a tendinous *origin* from the superior lateral portion of the posterior surface of the humerus along a line extending from the insertion of the teres minor as far as the groove for the radial (musculo-spiral) nerve, and from the aponeurotic arch formed by the lateral intermuscular septum as it crosses this groove. The constituent fibre-bundles descend, the superior vertically, the inferior obliquely, to be inserted on the dorsal and ventral surfaces of the proximo-lateral margin of the common tendon of insertion of the triceps.

The **medial head** has a fleshy *origin* from the posterior surface of the humerus below the radial (musculo-spiral) groove and from the dorsal surfaces of the medial and lateral intermuscular septa. The greater part of the fibre-bundles arising from this extensive area are inserted into the deep surface of the common tendon, but some extend directly to the olecranon and the articular capsule of the elbow. The slip attached to the capsule is sometimes called the **subanconeus** muscle.

Insertion.—The tendon of insertion of the triceps forms a flat band covering the dorsal surface of the distal two-fifths of the muscle. It also extends proximally between the long and lateral heads and on the deep surface of the former. This tendon is inserted into the olecranon and laterally, by a prolongation over the anconeus, into the dorsal fascia of the forearm.

Nerve-supply.—From the radial (musculo-spiral) nerve. The branch to the long head arises in the arm-pit and enters that margin of the muscle which is prolonged down from the lateral edge of the tendon, but which, because of the torsion of the muscle, comes to lie on the medial side. The nerve usually enters through several rami about the middle of the free portion of the long head. Somewhat more distally the radial nerve gives off a branch that enters, by two or three branches, the proximal portion of the medial head. A similar branch is given to the lateral head and other branches are given to the lateral and medial heads from that portion of the radial (musculo-spiral) nerve lying in the radial (musculo-spiral) groove.

Relations.—Near the shoulder the triceps is covered by the deltoid muscle. The long head passes between the teres major and teres minor muscles. The circumflex (dorsal) scapular vessels here pass medial, the circumflex humeral vessels and the axillary (circumflex) nerve lateral, to this head. More distally the muscle lies beneath the brachial fascia. It covers the radial groove of the humerus, in which run the radial (musculo-spiral) nerve and (superior) profunda brachii artery. Ventro-lateral to the muscle lie the deltoid, brachialis, brachio-radialis, and extensor carpi radialis muscles; ventro-medial, the coraco-brachialis, biceps, and brachialis muscles.

Action.—It extends the forearm. The leverage is of such a nature that force is sacrificed for speed of movement. The long head of the triceps also serves to adduct the arm and to hold the head of the humerus in the glenoid cavity.

Variations.—The scapular attachment may extend for a considerable distance down the axillary border of the scapula. Each of the heads may be more or less fused with neighbouring muscles. Frequently a fourth head is found. This may arise from the humerus, from the axillary margin of the scapula, from the capsule of the shoulder-joint, from the coracoid process, or from the tendon of the latissimus dorsi.

The *lattissimo-condyloideus* (dorso-epitrochlearis).—This muscle is found in about 5 per cent. of bodies. When well developed, it extends from the tendon of the latissimus dorsi to the brachial fascia, the triceps muscle, the shaft of the humerus, the lateral epicondyle, the olecranon, or the fascia of the forearm. It is innervated by a branch of the radial (musculo-spiral) nerve. It is a muscle normally present in some one of the forms above mentioned or in some similar form, in a large number of the inferior mammals. In the human body it is normally represented by a fascial slip from the tendon of the latissimus to the long head of the triceps or the brachial fascia.

The **anconeus.**—*Origin.*—By a short narrow tendon from the distal part of the back of the lateral epicondyle and the adjacent part of the capsular ligament of the elbow-joint.

Structure and Insertion.—The tendon of origin is prolonged on the deep surface and lateral border of the muscle. From this the fibre-bundles spread, the proximal transversely, the more distal obliquely, to be inserted into the radial side of the olecranon and an adjacent impression on the shaft of the ulna. Its superior fibre-bundles are usually continuous with those of the medial head of the triceps.

Nerve-supply.—By a long branch which arises in the radial (musculo-spiral) groove from the radial (musculo-spiral) nerve, passes through the medial head of the triceps, to which it gives branches, and enters the proximal border of the anconeus.

Action.—It aids the triceps in extending the forearm and draws the ulna laterally in pronation of the hand.

Relations.—The muscle lies immediately beneath the antibrachial fascia. It extends over the head of the supinator (brevis) and the elbow-joint and upper radio-ulnar joint.

Variations.—The extent of fusion of the muscle with the medial head of the triceps varies a good deal. It may also be fused with the extensor carpi ulnaris. It has been reported missing.

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B. intratendinea olecrani.—Within the tendon of the triceps near its insertion. More frequent than the following:—

B. subtendinea olecrani.—Between the tendon of the triceps and the olecranon and dorsal ligament of the elbow-joint. Inconstant.

B. epicondyli medialis dorsalis.—Between the medial epicondyle, the edge of the triceps, and the ulnar nerve. Rare.

B. m. anconei.—Between the tendon of origin of the muscle and the head of the radius. Frequent.

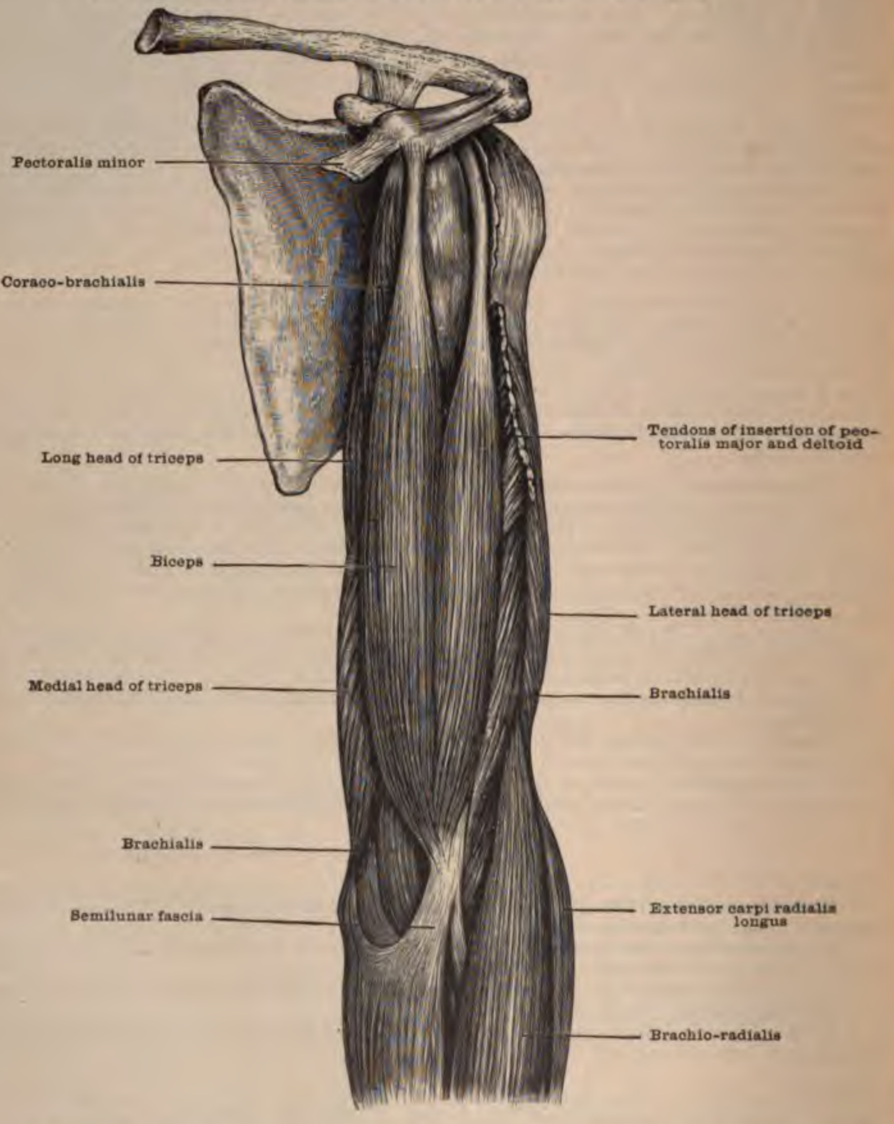
2. Ventral or Flexor Group

(Figs. 325, 326, 331, 333)

The muscles of this group are the coraco-brachialis, the biceps, and the brachialis. The **coraco-brachialis** (fig. 326) is a band-like muscle which extends from the coracoid process to the middle third of the shaft of the humerus. The **biceps** (fig. 325) arises by two heads: a short head, closely associated with the coraco-brachialis, from the coracoid process; a long head, by an extended tendon, from the supraglenoid tuberosity of the scapula. The fusiform belly which arises from the fusion of these two heads is inserted into the radius and into the fascia of the forearm. The **brachialis** (fig. 326) extends under cover of the biceps from the lower three-fifths of the shaft of the humerus to the coronoid process of the ulna. The muscles of this group are supplied by the musculo-cutaneous nerve. The brachialis also usually receives a branch from the radial nerve. The coraco-brachialis and the biceps flex the arm at the shoulder; the biceps and brachialis flex the forearm at the elbow.

The muscles of this group are found in most of the limbed vertebrates. In many of the lower forms the coraco-brachialis, which appears farther down in the vertebrate series than the biceps, has a more extensive insertion than in man. It may extend to the ulna (lizards) and may be subdivided into various muscles which correspond with the adductors of the thigh. The biceps, the place of which is taken in the lower vertebrates by a coraco-radial muscle, in most of the mammals presents two heads, the more lateral of which is attached by a tendon to the scapula above the shoulder-joint. This long tendon of the biceps lies primitively outside the capsule of the shoulder-joint, but in some of the higher mammals has come to lie within the capsule. In the biceps four elements may be recognised:—a coraco-radial, coraco-ulnar, gleno-radial, and gleno-ulnar. (Krause.) The development of these elements varies in different mammals.

Fig. 325.—Superficial Muscles of the Front of the Arm.

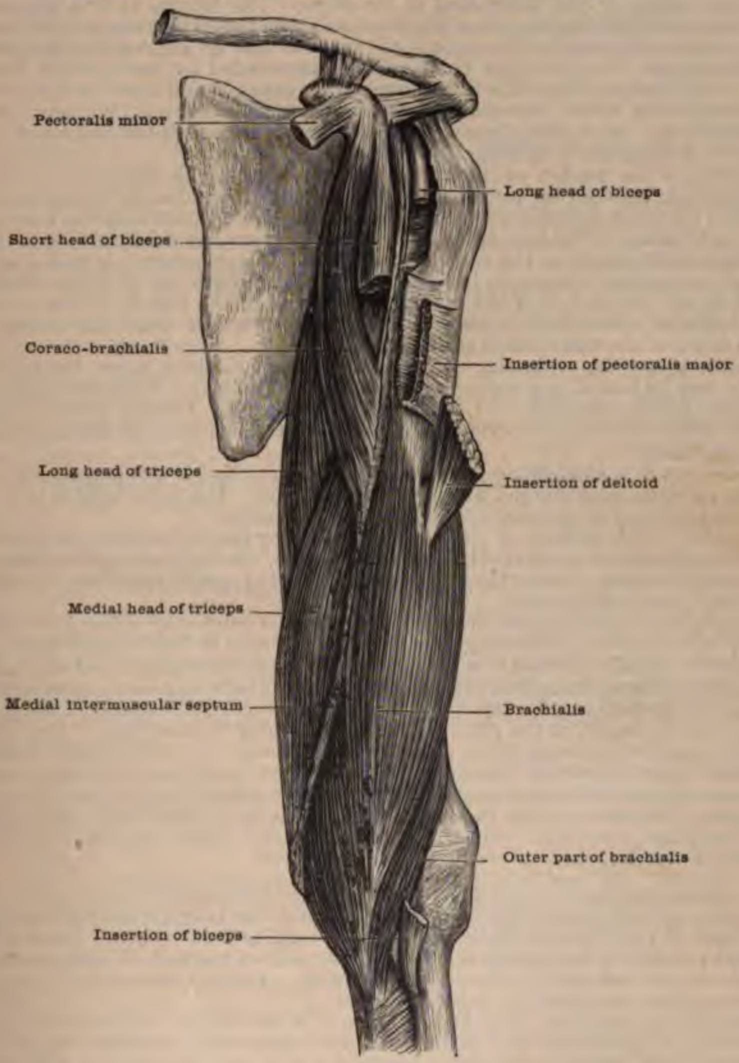

Pectoralis minor
Coraco-brachialis
Long head of triceps
Biceps
Medial head of triceps
Brachialis
Semilunar fascia
Tendons of insertion of pectoralis major and deltoid
Lateral head of triceps
Brachialis
Extensor carpi radialis longus
Brachio-radialis

The coraco-brachialis (fig. 326).—*Origin*.—(1) By a short tendon from the tip of the coracoid process of the scapula and (2) from the tendon of the short head of the biceps.

Insertion.—(1) By means of a strong tendon into the medial surface of the humerus immediately proximal to the middle of the shaft, and (2) often above this also into an aponeurotic band which extends from the tendon along the medial margin of the humerus, arches over the tendons of the latissimus dorsi and teres major, and is attached to the lesser tubercle of the humerus. When the attachment to the tubercle does not take place, the band becomes closely applied to the deep surface of the muscle.

Structure.—From the tendons of origin, which are usually closely associated, the fibre-bundles take an oblique, nearly parallel, course and are attached to the aponeurotic band above mentioned and to both surfaces of the flat tendon of insertion. This extends high into the muscle. The belly of the muscle usually shows some separation into a superficial and a deep portion, between which runs the musculo-cutaneous nerve. When this separation is well marked, the tendon of origin of the superior fasciculus may be distinct from that of the inferior fasciculus and the short head of the biceps, and the tendon of insertion may give a separate lamina to each fasciculus.

FIG. 326.—DEEP MUSCLES OF THE FRONT OF THE ARM


Pectoralis minor
Long head of biceps
Short head of biceps
Coraco-brachialis
Insertion of pectoralis major
Long head of triceps
Insertion of deltoid
Medial head of triceps
Medial intermuscular septum
Brachialis
Outer part of brachialis
Insertion of biceps

Nerve-supply.—From a branch of the musculo-cutaneous nerve, which enters the upper third of the medial border of the muscle, and passes across the constituent fibre-bundles about midway between their attachments.

Action.—Adducts and flexes the arm at the shoulder and helps to keep the head of the humerus in the glenoid fossa. When the arm has been rotated outwards, it acts as an internal rotator.

Relations.—The coraco-brachialis is largely covered by the deltoid and pectoralis major muscles. Below the inferior border of the latter it becomes superficial. Near its origin it lies between the pectoralis minor and the subscapularis muscles. More distally it lies medial to the humerus and in front of the chief brachial vessels and nerves. The musculo-cutaneous nerve usually runs through it.

Variations.—The humeral insertion of the muscle varies considerably. According to Wood, the coraco-brachialis consists primitively of three parts, which arise from the coracoid process and are inserted respectively into the upper, the middle, and the distal part of the humerus along the medial side. The superior division is most deeply, the inferior the most superficially, placed. In man the muscle is composed of parts of the middle and inferior divisions. The inferior division may be completely developed as far as the medial epicondyle. The superior division of the muscle is occasionally found. Slips from the coraco-brachialis to the brachialis have been seen. Complete absence of the muscle has been recorded.

The **biceps brachii** (figs. 325, 331).—The *short head arises* by a flat tendon closely associated with that of the coraco-brachialis from the coracoid process. From the dorso-medial surface of this tendon the fibre-bundles descend nearly vertically, though increasing in number, towards their attachment to the tendon of insertion. The fibre-bundles which arise highest on the tendon of origin are inserted highest on the tendon of insertion, while those which have the lowest origin have the lowest insertion.

The *long head arises* from the supraglenoid tuberosity and from the glenoid ligament by a long tendon (9 cm.) bifurcated at its origin. The tendon at first passes over the head of the humerus within the capsule of the joint, and then passes into the intertubercular (bicipital) groove, which is covered by the capsule of the joint and an expansion from the tendon of the pectoralis major. To this point the tendon is surrounded by the synovial membrane of the joint. After emerging from this the tendon slowly expands and from its dorsal concave surface arise fibre-bundles which, increasing in number, extend, somewhat obliquely, towards the tendon of insertion. As in case of the short head, here also the fibre-bundles which arise highest on the tendon of origin have the highest insertion.

Insertion.—The tendon of insertion begins usually in the distal quarter of the arm as a vertical septum between the two heads of the muscle. More distally this broadens out on each side into a flattened aponeurosis. The fibre-bundles are inserted into the sides of the septum and on each surface of the aponeurosis—those of the long head chiefly on the deep surface, those of the short head chiefly on the superficial surface. The aponeurosis is continued into a strong, flattened tendon which descends between the brachio-radialis and pronator teres muscles to be inserted on the dorsal half of the bicipital tuberosity of the radius. From the medial border of the tendon an aponeurotic expansion, the **lacertus fibrosus** (semilunar fascia), is continued into the fascia of the ulnar side of the forearm.

Lacertus Fibrosus

Nerve-supply.—By a branch from the musculo-cutaneous nerve for each head. These branches may be bound in a common trunk for some distance. They enter the deep surface of the muscle in the proximal half, often by several rami. Usually there is a distinct intramuscular fissure for the reception of the branches to each head and the blood-vessels which accompany them.

Action.—It is a chief flexor of the arm at the elbow and is also a supinator of the forearm. This last action is most marked when the arm is flexed. The short head is to a slight extent a flexor, the long head an abductor, of the arm at the shoulder.

Relations.—The tendons of origin are concealed by the pectoralis major and deltoid muscles. Beyond this the muscle is covered by the fascia brachii. In the lower part of the arm it lies upon the brachialis muscle. Upon the medial margin lie the coraco-brachialis muscle, the brachial vessels, and the median nerve.

Variations.—Variations are frequent. The whole muscle or either head may be missing, but such cases are rare. The long head may extend only to the bicipital groove. Frequently the muscle is partially divided into the four primitive portions mentioned above (p. 371). The two heads may be separate from origin to insertion. There may be an accessory head (1 in 10 subjects—Le Double) which arises from the coracoid process, the capsule of the joint, the tendon of the pectoralis major, or the shaft of the humerus near the insertion of the coraco-brachialis. In most instances the origin takes place above the origin of the brachialis from the humerus. Sometimes several accessory heads are seen. Marked variation of insertion is less frequent, but occasionally a supernumerary slip may go to the medial intermuscular septum or the medial epicondyle. The fusion of the biceps with neighbouring muscles (pectoralis major and minor, coraco-brachialis, brachialis, palmaris longus, pronator teres, brachio-radialis) by means of tendinous or muscular slips has been frequently reported.

The **brachialis** (fig. 326).—*Origin.*—(1) From the distal three-fifths of the front of the humerus, (2) from the medial intermuscular septum, and (3) from the lateral intermuscular septum proximal to the heads of the brachio-radialis and extensor carpi radialis longus. Proximally it sends up a pointed process on the lateral side of the insertion of the deltoid and another between the insertions of the deltoid and the coraco-brachialis. Distally the area of origin stops a little above the capitulum and the trochlea.

Structure and Insertion.—The fibre-bundles arise directly from this area of origin, except near the insertion of the deltoid and on the medial margin, where tendinous bands are developed. The fibre-bundles descend, the middle vertically, the medial obliquely outwards, the lateral still more obliquely inwards. The tendon of insertion appears on the dorsal side of the lateral edge of the muscle in its lower fourth. Continuous with this stronger lateral portion of the tendon more distally a thinner band appears upon the ventral surface of the muscle above the joint. The tendon becomes thick as it passes distally, is closely united to the capsule of the elbow-joint, and is attached to the ulnar tuberosity. In addition to the main tendon, some of the deeper fibre-bundles of the muscle and some of those coming from the lateral intermuscular septum are attached by short tendinous bands to the coronoid process.

Nerve-supply.—From the musculo-cutaneous nerve by a branch which enters the ventral surface of the muscle near the junction of the upper and middle thirds of the medial border. In addition the radial (musculo-spiral) nerve usually sends a small branch into the distal lateral portion of the muscle.

Action.—To flex the forearm.

Relations.—It lies behind the biceps, on each side of which it projects. The distal lateral portion of the muscle is grooved by the brachio-radialis, which here is closely applied to it. The radial (musculo-spiral) nerve runs between these two muscles. On the medial side run the brachial vessels and median nerve.

Variations.—It may be divided into two distinct heads continuous with the projections on each side of the deltoid tuberosity. A great number of supernumerary slips have been recorded. These may be attached to the radius, ulna, fascia of the forearm, capsule of the joint, brachio-radialis, and extensor carpi radialis muscles. It may be partially fused with neighbouring muscles. It has also been reported absent.

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1st week

B. m. coraco-brachialis.—Between the subscapularis muscle, the tendon of the coraco-brachialis, and the coracoid process. Frequent.

B. bicipito-radialis.—Between the ventral half of the radial tuberosity and the tendon of the biceps. Constant.

B. cubitalis interossea.—Between the tendon of the biceps and the ulna and the neighbouring muscles. Frequent.

C. MUSCULATURE OF THE FOREARM AND HAND

(Figs. 327–340)

The muscles of the forearm arise in part from the humerus, in part from the radius and ulna. Their bellies lie chiefly in the proximal half of the forearm. They are divisible into two groups:—a dorso-radial, composed of extensors of the hand and fingers and supinators of the forearm; and a volar, composed of flexors of the hand and fingers and pronators of the forearm. The brachio-radialis, which belongs morphologically with the former group, is physiologically a flexor.

The two groups are separated on the medial side of the back of the forearm by the dorsal margin of the ulna (figs. 327, 330). Ventrally they are separated by the insertions of the biceps and brachialis and by an intermuscular septum (figs. 327, 331).

The **dorso-radial group** represents primarily the dorsal musculature of the forearm, and is supplied by the great dorsal nerve (the radial) of the brachial plexus. The muscles arise from the distal lateral side of the humerus in front of the lateral intermuscular septum of the arm and from the back of the radius and ulna. A superficial and a deep set are recognised. The superficial muscles arise from the humerus (fig. 328). From them tendons extend to the distal end of the radius (brachio-radialis), to the radial and ulnar sides of the carpus (extensor carpi radialis longus and brevis and the extensor carpi ulnaris), and to the backs of the digits (extensor digitorum communis and extensor digiti quinti proprius). The muscles of the deep group (fig. 330) arise from the ulna* and are inserted into the radius (supinator), thumb (abductor pollicis longus, extensor pollicis longus and brevis), and index-finger (extensor indicis proprius).

The **volar musculature** arises from the medial epicondyle and from the front of the radius and ulna, and is attached to the front of the skeleton of the forearm and hand. It is supplied by branches from the ulnar and median nerves. The muscles lie in four planes. The muscles of the most superficial set (fig. 331), the pronator teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris, arise from the medial epicondyle of the humerus and from the ulna, and send tendons to the radius, carpus, and palmar fascia; that of the second layer (fig. 332), the flexor digitorum sublimis, arises from the medial epicondyle, ulna, and radius, and sends tendons to the second row of phalanges of the fingers; those of the third layer (fig. 333), the flexor digitorum profundus and flexor pollicis longus, arise from the radius and ulna, and send tendons to the terminal phalanges of the fingers and the thumb; and that of the fourth layer (fig. 338), the pronator quadratus, extends from the ulna to the radius. The muscles of the first two planes are closely united near their epicondylar origin. They form a group separated from the deeper muscles by a membrane in which run the chief blood-vessels and nerves of the ventral side of the forearm.

In the **hand,** in addition to the tendons of the muscles of the forearm mentioned above (fig. 337), there are several sets of intrinsic muscles. About the metacarpal of the thumb (figs. 336, 337, 338) is grouped a set of muscles which extend from the carpus and metacarpus to the metacarpal and first phalanx of the thumb. A similar set of muscles is grouped about the metacarpal of the little finger (figs. 336,

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*The supinator also arises indirectly from the lateral epicondyle of the humerus.

336, 337). These sets of muscles give rise respectively to the thenar and hypothenar eminences. Between the metacarpals lies a series of dorsal and palmar interosseous muscles (figs. 338, 339, 340) which are inserted into the first row of phalanges and into the extensor tendons. From the tendons of the deep flexor of the forearm a series of lumbrical muscles passes to the radial side of the bases of the first row of phalanges of the fingers and into the extensor tendons (figs. 336, 334). These various muscles serve to abduct, adduct, flex, and extend the digits. In addition to these deeper skeletal muscles of the hand there is a subcutaneous muscle over the hypothenar eminence (fig. 336). Of the muscles of the hand, all are supplied by the ulnar nerve except two or three of those of the thumb and the two more radial lumbricals.

An arrangement of the muscles of the forearm in which the dorsal extensor-supinator musculature extends proximally on the radial side of the arm to the distal extremity of the humerus, and the volar flexor-pronator musculature similarly on the ulnar side, is characteristic of all limbed vertebrates and is associated with the supine position of the forelimb characteristic of quadrupeds. In amphibia and reptiles the musculature terminates distally on the carpus and in the aponeuroses of the hand. In the higher forms special tendons are differentiated for those muscles of the forearm which act on the fingers. On the back of the hand in many vertebrates short extensor muscles are found running from the carpus to the phalanges. On the volar surface a complex musculature is found in all forms which have freely movable fingers. In animals which walk on the ends of the fingers, especially in the hoofed animals, the intrinsic musculature of the hand is greatly reduced. The phylogenetic development of the muscles of the forearm and hand is too complex a subject to be briefly summarised. The phylogeny of the forearm flexors and the palmar musculature has been studied recently by McMurrich. In his papers a summary of the literature on the subject may be found.

The **fasciæ** and the general relations of the musculature of the forearm and hand may be followed in the cross-sections fig. 327.

The **tela subcutanea** contains a moderate amount of fat in the upper part of the forearm. This grows less in amount as the wrist is approached. On the back of the hand it contains little fat. In the palm and on the volar surface of the fingers a moderate amount of fat is embedded between dense vertical bundles of fibres which serve to unite the skin to the fascia. Except on the volar surface of the hand and on the backs of the terminal phalanges, the tela is but loosely united to the underlying fascia.

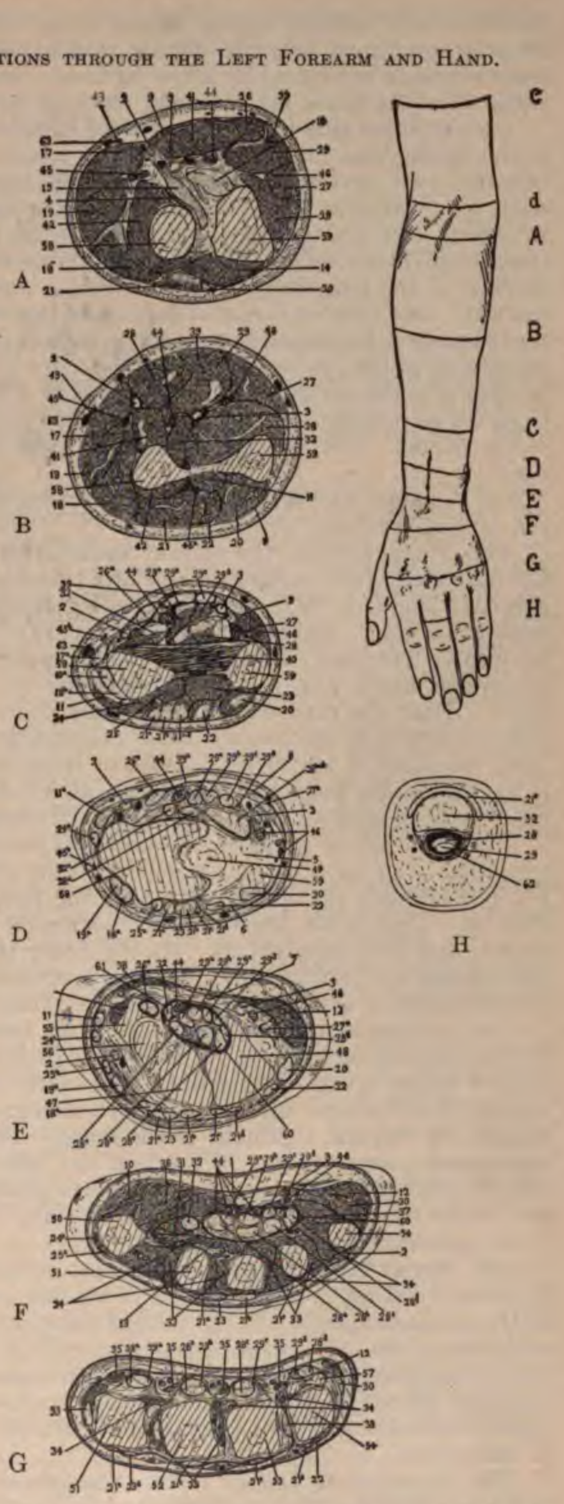
The **bursa subcutanea olecrani** lies over the dorsal surface of the olecranon. Subcutaneous bursæ are also frequently found over the knuckles (**b. subcutaneæ metacarpophalangeæ dorsales**) and the proximal joints of the fingers (**b. subcutaneæ digitorum dorsales**).

The **antibrachial fascia** encloses the muscles of the forearm in a cylindrical sheath, composed in the main of circular fibre-bundles, but strengthened by longitudinal and oblique bundles extending in from the condyles of the humerus, the olecranon, the lacertus fibrosus of the biceps, and the tendon of the triceps. The fascia of the forearm is attached to the dorsal surface of the olecranon and to the subcutaneous margin of the ulna. Above, it is continued into the fascia of the arm; below, into the fascia of the hand. From the antibrachial fascia in the upper half of the forearm a fibrous septum extends between the dorso-radial and the ventral muscle groups to the radius. In the radial septum below the elbow a branch of communication extends between the superficial and deep veins of the arm. That part of the fascia overlying the dorso-radial group of muscles is much denser than that covering the ventral group, except where the latter is strengthened by the lacertus fibrosus. In addition to the main radial septum other septa descend between the underlying muscles from the antibrachial fascia. These septa are best marked near the attachment of the muscles to the humerus. Here the fascia is firmly fused to the muscles.

Dorsally the antibrachial fascia is strengthened at the wrist by transverse fibres which extend from the radius to the styloid process of the ulna, the triquetrum (cuneiform), and pisiform, and give rise to the **dorsal ligament of the carpus** (posterior annular ligament). From this ligament septa descend to the radius and ulna and convert the grooves in these bones into osteo-fibrous canals which lodge the tendons of the various muscles extending to the wrist and hand.

On the **back of the hand** there is spread a fascia composed of two thin fascial sheets between which the extensor tendons are contained. Between the tendons these sheets are more or less fused. On the backs of the fingers the fascia blends with the extensor tendons and the associated aponeurotic expansions from the interosseous and lumbrical muscles. Between the fingers it is continued into

FIG. 327, A–G.—TRANSVERSE SECTIONS THROUGH THE LEFT FOREARM AND HAND.



H. Transverse section through the first phalanx of the middle finger, diagrammatic, with the cavity of the synovial sheath of the flexor tendons distended.

The regions through which these sections pass are indicated in the diagram. *c* and *d* in the diagram show the regions through which pass sections C and D, fig. 323 (p. 366).

1. Palmar aponeurosis. 2. Radial artery. 3. Ulnar artery. 4. Bursa bicipito-radialis. 5. Articular disk. 6. Dorsal carpal ligament. 7. Transverse carpal ligament. 8. Volar carpal ligament. 9. Antibrachial fascia. 10. Abductor pollicis brevis. 11. Abductor pollicis longus—a, tendon. 12. Abductor digiti quinti. 13. Adductor pollicis. 14. Anconeus. 15. Biceps, tendon. 16. Brachialis, tendon. 17. Brachioradialis—a, tendon. 18. Extensor carpi radialis brevis—a, tendon. 19. Extensor carpi radialis longus—a, tendon. 20. Extensor carpi ulnaris. 21. Extensor digitorum communis—a, tendon for second finger; b, tendon for third finger; c, tendon for fourth finger; d, tendon for fifth finger; e, digital aponeurosis. 22. Extensor digiti quinti proprius. 23. Extensor indicis proprius 24. Extensor pollicis brevis—a, tendon. 25. Extensor pollicis longus—a, tendon. 26. Flexor carpi radialis—a, tendon. 27. Flexor carpi ulnaris—a, tendon. 28. Flexor digitorum profundus —a, tendon for second finger; b, tendon for third finger; c, tendon for fourth finger; d, tendon for fifth finger. 29. Flexor digitorum sublimis—a, tendon for second finger; b, tendon for third finger; c, tendon for fourth finger; d, tendon for fifth finger. 30. Flexor digiti quinti brevis. 31. Flexor pollicis brevis. 32. Flexor pollicis longus—a, tendon. 33. Interossei dorsales. 34. Interossei volares. 35. Lumbricales. 36. Opponens pollicis. 37. Opponens digiti quinti. 38. Palmaris brevis. 39. Palmaris longus—a, tendon. 40. Pronator quadratus. 41. Pronator teres. 42. Supinator. 43. Lateral antibrachial cutaneous nerve. 44. Median nerve. 45. Radial nerve—a, deep radial nerve; b, superficial radial nerve. 46. Ulnar nerve. 47. Os capitatum (magnum). 48. Os hamatum (unciform). 49. Os lunatum (semilunar). 50. I metacarpal. 51. II metacarpal. 52. III metacarpal. 53. IV metacarpal. 54. V metacarpal. 55. Os multangulum majus (trapezium). 56. Os naviculare. 57. Sesamoid bones of fifth digit. 58. Radius. 59. Ulna. 60. Tendon-sheath of the long digital flexors. 61. Tendon-sheath of the flexor pollicis longus. 62. Digital tendon-sheaths. 63. Cephalic vein.

the transverse fasciculi of the palmar aponeurosis. At the sides of the hand the fascia is continued into the thenar and hypothenar fasciæ. Each dorsal interosseous muscle is covered by a special fascial membrane which is separated by loose tissue from the fascia investing the extensor tendons.

On the **volar side of the forearm** for some distance above the wrist the tendons of the flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris run between two layers of the fascia. The fascia is much strengthened at the wrist by transverse fibres which give rise to the **volar ligament of the carpus.** It is here attached on the radial side to the navicular and greater multangular (trapezium) bones, on the ulnar to the pisiform and hamatum (unciform). Over the tendons of the long flexors of the fingers a deep transverse fascial septum is well marked. Both the antibrachial fascia and the deep fascial septum are attached to the **transverse ligament of the carpus** (anterior annular ligament). This dense band extends from the pisiform bone and the hamulus of the hamatum (unciform) to the tuberosity of the navicular and the tuberosity of the greater multangular (trapezium). It serves to complete an osteo-fibrous canal through which pass the flexor tendons of the fingers. Between the two volar carpal ligaments run the ulnar artery and nerve.

On the **palm of the hand** the ensheathing fascia presents three distinct areas —a central, a lateral, and a medial.

The central portion, the **palmar aponeurosis,** is composed chiefly of bundles of fibrous tissue which radiate superficially towards the fingers from the tendon of the palmaris longus or from a corresponding region of the forearm fascia when this muscle is absent. Between these bundles are others which arise from the transverse ligament. The deep surface of the fascia is composed of a thin incomplete layer of transverse fibres which serve to continue the transverse fibres of the forearm fascia. Near the capitula of the metacarpals this layer becomes much stronger and constitutes a ligamentous band (**superficial transverse ligament** of Poirier). Near the bases of the digits bundles of transverse fibres (**fasciculi transversi**) lie in the webs of the fingers and constitute an incomplete transverse ligament separated by a distinct interval from the superficial transverse ligament.

From the palmar aponeurosis numerous processes are sent in towards the deeper structures. Of these, the most important are those continued into a fibrous sheath which surrounds the space containing the long flexor tendons and the lumbrical muscles. This dense fibrous sheath is united by fibrous processes to the third, fourth, and fifth metacarpals. As the flexor tendons diverge and the ends of the metacarpals are approached, numerous processes descend from the palmar aponeurosis to the transverse capitular ligament. These serve to hold the tendons in place. On the volar surface of the fingers the fascia serves to complete osteo-fibrous canals for the long flexor tendons. The ventral surface of the first and second phalanges of each finger is slightly grooved. The fascia is firmly united on each side to the margin of the groove, and over the groove forms a semicylindrical, strong, fibrous sheath, the **vaginal ligament** of the finger. This sheath is strengthened by transverse bands over the bases of the first and second phalanges (**annular ligaments**) and by cruciate bands over the shafts of the phalanges (**cruciate ligaments**). Over the interphalangeal joints the sheath is thin, but is strengthened by crucial bands which permit of freedom of motion.

The **thenar fascia** is a thin membrane covering the short muscles of the thumb. It is continued above into the fascia of the forearm, medially is fused with the tendon of the palmaris longus and the palmar aponeurosis, and extends as a septum to be attached to the third metacarpal. Laterally it is attached to the first metacarpal and is continued into the dorsal fascia of the hand. It is fused with an aponeurosis from the tendon of the abductor pollicis longus. Distally it is continued into the vaginal ligament of the long flexor of the thumb. Superficially it is closely adherent to the skin.

The **hypothenar fascia** invests the palmar muscles of the little finger. It is continued from the ulnar margin of the fifth metacarpal over the muscles of the little finger to the palmar aponeurosis, and, by means of a septum, to the radial side of the fifth metacarpal. Proximally, it is attached to the hamatum (unciform); distally, it extends into the vaginal ligament of the tendon of the fifth digit.

A deeply seated suprametacarpal fascial layer, or **deep palmar fascia,** covers the interosseous muscles and is attached to the volar surface of the metacarpal bones.

In addition to the fasciæ mentioned, intermuscular septa serve to separate more or less completely the various intrinsic muscles of the hand.

MUSCLES

1. DORSAL-RADIAL GROUP

(Figs. 328–333)

The muscles of this group lie in two chief layers, a superficial and a deep.

a. SUPERFICIAL LAYER

(Figs. 328, 331, 332)

The muscles of this layer, closely associated at their origins, extend from the radial side of the distal end of the humerus to the distal extremity of the radius, the carpus, and the fingers. They are divisible into a lateral, an intermediate, and a medial set.

Lateral set.—To this belong three muscles, the brachio-radialis, extensor carpi radialis longus and brevis. The **brachio-radialis** (fig. 331) is a superficial fusiform muscle which arises from the lateral epicondylar ridge of the humerus and is inserted into the base of the styloid process of the radius. The **extensor carpi radialis longus** (fig. 332) is a narrow, fusiform muscle which extends along the radial margin of the forearm, partly under cover of the brachio-radialis. It arises from the lateral epicondylar ridge of the humerus, and is inserted into the second metacarpal bone. The **extensor carpi radialis brevis** (fig. 328) is a band-like muscle more dorsally placed than the last at the radial side of the arm. It extends from the lateral epicondyle to the bases of the second and third metacarpals. These muscles are supplied by branches of the radial nerve which arise proximal to the passage of the deep radial (posterior interosseous) through the supinator muscle. Distally this set of muscles is separated from the intermediate set by the long abductor and the extensors of the thumb, which pass from an origin under the latter set over the tendons of the radial extensors to the thumb.

The **intermediate set.**—This consists of the thick, flattened **extensor digitorum communis** and the slender **extensor digiti quinti proprius** (fig. 328). They arise from the lateral epicondyle, and are inserted into the backs of the fingers.

The **medial set** consists of one muscle, the fusiform **extensor carpi ulnaris,** which arises from the lateral epicondyle of the humerus and is inserted into the back of the base of the fifth metacarpal.

The intermediate and medial sets of muscles are supplied by branches from the ramus profundus of the radial nerve after this has passed through the supinator muscle.

In the leg the lateral set of the superficial layer is represented by the tibialis anterior. The intermediate set is represented by the long digital extensor of the toes. The single muscle which constitutes the medial set is represented by the peroneal muscles.

The brachio-radialis (supinator radii longus) (figs. 328, 331).—*Origin.*—From the upper two-thirds of the lateral epicondylar ridge of the humerus and from the front of the lateral intermuscular septum.

Insertion.—Into the lateral side of the base of the styloid process of the radius.

Structure.—The constituent fibre-bundles arise directly from the septum and by short tendinous bands from the epicondylar ridge, extend downwards and ventrally, and terminate in a penniform manner on a tendon which extends high on the deep surface of the muscle. This tendon becomes free about the middle of the forearm as a broad, flat band. This becomes narrow as the tendon winds about the radius from the volar to the lateral surface. Before its insertion it expands laterally and is connected with neighboring ligaments. The free surface of the muscle faces laterally at its origin, but, owing to the torsion, ventrally in the forearm. The tendon, however, is turned again so that at the insertion it faces laterally once more.

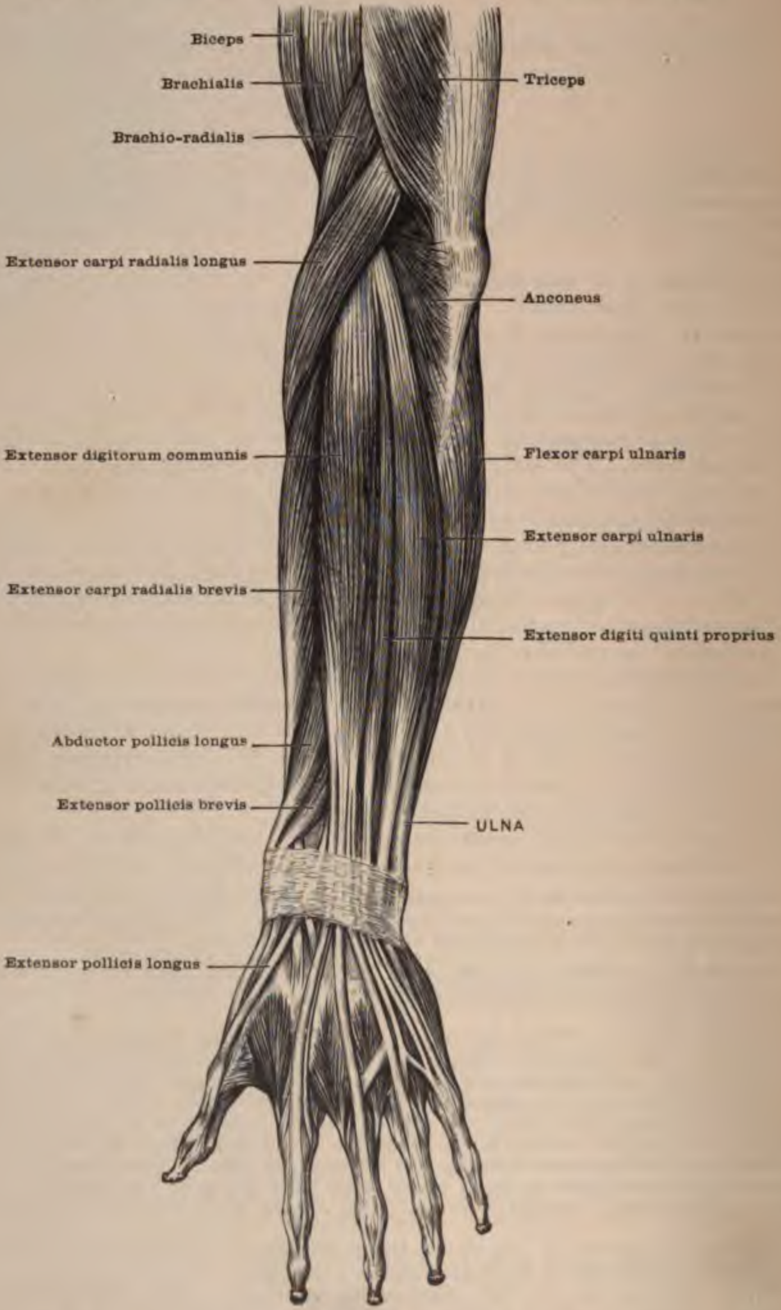
Nerve-supply.—From a branch of the radial nerve (musculo-spiral) which enters the proximal third of the muscle on its deep surface.

Action.—To flex the forearm. This action is strongest when the forearm is pronated. It acts as a supinator only when the arm is extended and pronated. It then serves to put the arm in a state of semi-pronation. When the arm is flexed, it acts as a pronator.

Relations.—The muscle is superficially placed on the ventro-lateral surface of the forearm. Its tendon of insertion, however, is covered by the long abductor and the short extensor of the thumb. Near its origin (fig. 328) it lies lateral to the brachialis. In the intervening tissue run the radial nerve and the terminal branch of the profunda brachii artery. Dorsally and laterally lies the medial head of the triceps. More distally the muscle overlies the extensor carpi radialis longus. It crosses the supinator, pronator teres, and flexor pollicis longus muscles. Beneath its medial edge lie the radial vessels and nerve.

Variations.—The humeral origin may extend half-way up the shaft. The radial insertion may be as high as the middle of the shaft or descend to the lesser multangular, navicular, or third metacarpal. In about 7 per cent. of bodies (Le Double) the tendon of insertion divides into two or three slips which are inserted on the styloid process of the radius. Occasionally the radial nerve passes between these slips. An accessory slip may pass to the fascia of the forearm. The muscle may be doubled throughout its length and it may be missing. It may be connected by accessory slips with neighbouring muscles, the deltoid, brachialis, long abductor of the thumb, or long radial carpal extensor. The slip most frequently found goes to the brachialis.

FIG. 328.—MUSCLES OF THE RADIAL SIDE AND THE BACK OF THE FOREARM.


Biceps
Brachialis
Brachio-radialis
Triceps
Extensor carpi radialis longus
Anconeus
Extensor digitorum communis
Flexor carpi ulnaris
Extensor carpi ulnaris
Extensor carpi radialis brevis
Extensor digiti quinti proprius
Abductor pollicis longus
Extensor pollicis brevis
ULNA
Extensor pollicis longus

The extensor carpi radialis longus (figs. 328, 329, 332).—*Origin.*—From the lower third of the lateral epicondylar ridge, the lateral intermuscular septum, the overlying fascia, and from the front of the tendons of the extensor carpi radialis brevis and the extensor communis digitorum which arise from the lateral epicondyle.

Structure and Insertion.—The fibre-bundles are inserted in a penniform manner on both surfaces of a tendon which first appears on the lateral border of the deep surface of the muscle, becomes free above the middle of the forearm, and descends, closely applied to the tendon of the short radial carpal extensor, to the second compartment beneath the dorsal carpal ligament, through which it passes to its insertion into the base of the second metacarpal near the radial border. The outer surface of the muscle faces at first laterally, then ventrally.

Nerve-supply.—By one or two branches which arise from the radial (musculo-spiral) nerve as it passes between the brachialis and brachio-radialis. The nerve enters the deep surface of the muscle in the proximal part of the middle third.

Action.—To extend and abduct the hand. It steadies the wrist when the flexors act on the fingers. It is a flexor of the forearm; a supinator when the forearm is extended, a pronator when it is flexed.

Relations.—It is covered by the brachio-radialis near the elbow. Below it becomes superficial except where crossed by the tendons of the muscles of the thumb. (For the relations to the short radial carpal extensor see below.)

Variations.—The humeral attachment may be more extensive than that indicated above. The tendon of insertion may send a band to the third or to the fourth metacarpal or to the multangulum majus (trapezium). The muscle may be fused, partly or completely, with the short radial extensor. It may send a slip to the abductor pollicis longus or to some of the interossei.

The extensor carpi radialis brevis (figs. 328, 329).—*Origin.*—From a band which descends on its deep surface from the common extensor tendon attached to the lateral epicondyle, from the intermuscular septa surrounding its head, and from the radial collateral ligament of the elbow-joint.

Structure and Insertion.—The fibre-bundles converge obliquely towards a tendon which appears high up on the dorso-lateral surface of the muscle. Towards the lower third of the forearm this tendon becomes a free, strong band closely applied to the under surface of the tendon of the long radial extensor, and with this passes through the second compartment beneath the dorsal ligament of the carpus, diverging as it does so towards its insertion into the back of the bases of the second and third metacarpal bones.

Nerve-supply.—A branch is supplied to the muscle from the deep radial (posterior interosseous) nerve before this enters the supinator (brevis). The branch enters the middle third of the medial margin of the muscle by two or three rami.

Action.—To extend the hand and, to a slight extent, to flex the forearm.

Relations.—In its proximal portion the muscle is placed with a medial surface towards the common extensor, a deep towards the supinator (brevis) and pronator teres, and a dorso-lateral towards the long radial extensor. More distally the muscle and its tendon become flattened about the radius and partly covered by the long radial extensor and its tendon.

In the distal quarter of the forearm the tendons of these two muscles are crossed by the long abductor and the short extensor of the thumb. Beneath the dorsal carpal ligament the tendon of the short radial extensor is crossed by the tendon of the long extensor of the thumb.

Variations.—The tendon often sends no slip to the second metacarpal. Fusion of the two radial extensors is frequent. The fused muscle may have from one to four tendons. The **extensor carpi radialis intermedius** of Wood is a muscle which arises, rarely directly from the humerus, but not infrequently as a slip from one or both radial extensors. It is inserted into the second or third metacarpal bone or into both. The **extensor carpi radialis accessorius** is a muscle which has an origin like the extensor intermedius, but which terminates on the base of the metacarpal or first phalanx of the thumb, the short abductor of the thumb, or some neighbouring structure.

The extensor digitorum communis (figs. 328, 329).—*Origin.*—From a tendon attached to the lateral epicondyle, from the fascia of the forearm, and from intermuscular septa which lie between the head of the muscle and the short radial extensor, the extensor of the little finger, and the supinator muscles.

Insertion.—By four tendons into the bases of the phalanges of the fingers.

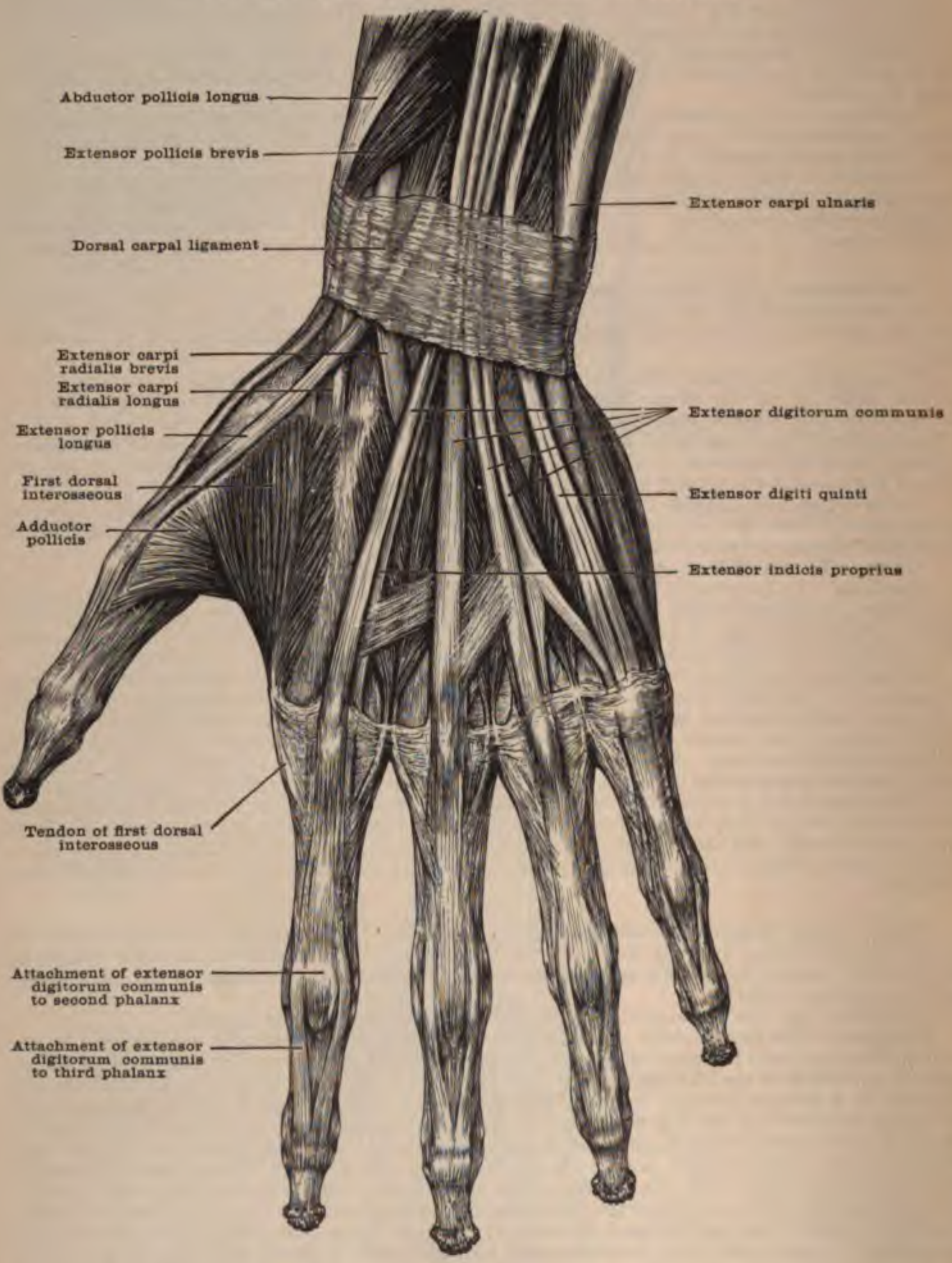
Structure.—The fibre-bundles arise from the interior of the pyramidal case formed by the tendon, the fascia, and intermuscular septa, and pass distally to converge on four tendons which begin in the middle of the forearm, become free a little above the wrist, pass under the dorsal carpal ligament in a groove common to them and the tendon of the extensor indicis proprius, and diverge to the backs of the fingers. Opposite the metacarpo-phalangeal joint each tendon gives rise on its under surface to a band which becomes attached to the base of the first phalanx of its respective digit. The tendon is also closely bound to the joint by fibrous bands connected with the palmar fascia. On the dorsum of the first phalanx the tendon expands and is bound to an aponeurotic extension from the interosseous and lumbrical muscles. The tendon divides into three bands. The middle band passes to the base of the second phalanx, the lateral bands pass laterally around the joint to be inserted into the back of the base of the third phalanx. The lateral bands are bound to the second joint by a thin layer of transverse and oblique fibres.

An obliquely transverse band usually passes from the tendon of the index to that of the middle finger above the heads of the metacarpals. The tendon to the index finger is united to the tendon of the extensor indicis proprius opposite the metacarpo-phalangeal articulation. The tendon to the ring finger usually sends a slip to join the tendon of the middle finger. The fourth tendon lies near that of the ring finger and divides into two slips, one of which joins the tendon of the ring finger and one goes to the little finger to join the tendon of the extensor digiti quinti proprius.

Nerve-supply.—From a branch which arises from the deep radial (posterior interrosseous) nerve as it emerges from the supinator (brevis) muscle. From this several twigs enter the deep surface of the middle third of the belly. Often the nerve is bound up with the nerve to the extensor of the little finger and the ulnar extensor. On the other hand, there may be several separate branches to the muscle.

Action.—The muscle extends the two terminal phalanges on the basal, the basal on the metacarpus, and the hand at the wrist. The extensor action is strongest on the first phalanx.

FIG. 329.—TENDONS UPON THE DORSUM OF THE HAND.


Abductor pollicis longus
Extensor pollicis brevis
Extensor carpi ulnaris
Dorsal carpal ligament
Extensor carpi radialis brevis
Extensor carpi radialis longus
Extensor digitorum communis
Extensor pollicis longus
First dorsal interosseous
Extensor digiti quinti
Adductor pollicis
Extensor indicis proprius
Tendon of first dorsal interosseous
Attachment of extensor digitorum communis to second phalanx
Attachment of extensor digitorum communis to third phalanx

The cross-bands between the tendons hinder the independent extension of the middle and ring fingers, while the special extensors of the index and little fingers make the movements of these fingers freer.

Relations.—It is superficially placed. Under it lie the deep muscles of the back of the forearm, the interosseous vessels, and the deep radial (posterior interosseous) nerve. It lies between the short radial carpal extensor and the extensor of the little finger.

Variations.—There is considerable variation in the extent of isolation of the parts going to the various fingers. That to the index-finger is the one most frequently isolated. At times the tendon to the index or little finger may be wanting. More frequently one or more of the tendons subdivides to be attached to two or more fingers or to the thumb. The connections between the tendons on the back of the hand vary greatly.

The extensor digiti quinti proprius (extensor minimi digiti) (figs. 328, 329).—*Origin.*—Chiefly from the septum between it and the common extensor, but also in part from the septum between it and the extensor ulnaris and from the overlying fascia.

Structure and Insertion.—The fibre-bundles descend in a narrow band which begins near the neck of the radius. They are inserted into the side of a tendon which begins high on the ulnar margin of the muscle. The most distal fibre-bundles extend nearly to the wrist-joint. The tendon passes through the fifth compartment beneath the dorsal carpal ligament, and extends on the back of the fifth metacarpal to the base of the first phalanx of the little finger, where it is joined by a slip from the fourth tendon of the common extensor. The insertion of the tendon is like that of the tendons of the common extensor.

Nerve-supply.—By a branch from the deep radial (posterior interosseous) nerve. From this filaments arise which enter the middle third of the fleshy portion of the muscle on its deep surface.

Action.—It acts as a portion of the common extensor, but, owing to its separation, independent movement of the little finger is possible.

Relations.—It lies between the common extensor and the ulnar extensor and upon the deep muscles of the back of the forearm.

Variations.—Absence is not very frequent; blending with the common extensor is frequent. Its tendon often divides into two or more slips. The belly may also be doubled. It may have a supplementary origin from the ulna. A tendon slip to the ring-finger is frequently found.

The extensor carpi ulnaris (figs. 328, 329).—*Origin.*—By two heads: one from the inferior dorsal portion of the epicondyle by an aponeurotic band attached below the tendon of the common extensor, from the enveloping fascia, and from the septa between it and the extensor digiti quinti, anconeus, and supinator (brevis); the other from the proximal three-fourths of the dorsal border of the ulna.

Structure and Insertion.—The fibre-bundles descend in an osteo-fascial compartment bounded by the dorsal surface of the ulna, the fascia of the forearm, the dense fascia overlying the ulnar origin of the muscles of the thumb, and the origin of the extensor indicis. The tendon commences high in the muscle and appears on the radial border of the middle third of the back of its belly. The fibre-bundles are inserted in a penniform manner on the ulnar border and deep surface of the tendon as far as the wrist. Here the tendon enters the sixth osteo-fibrous canal beneath the dorsal carpal ligament in a special groove on the outer side of the styloid process of the ulna. It is inserted into the base of the fifth metacarpal.

Nerve-supply.—By a branch which arises from the deep radial (posterior interosseous) nerve as this emerges from the supinator (brevis) muscle. Several filaments enter the deep surface of the muscle in the middle third.

Action.—To extend and abduct the hand.

Relations—It occupies a superficial position on the ulnar side of the extensors of the forearm. Beneath it lie the deep muscles of the back of the forearm and the posterior surface of the ulna.

Variations.—It may receive a slip from the triceps or be fused with the anconeus or with the extensor of the little finger. More frequently it is doubled, partially or completely. An accessory tendon may go to the first phalanx of the little finger, to the head of the fifth metacarpal, to the fourth metacarpal, to the extensor tendon of the little finger, or to the fascia over the opponens digiti quinti. The muscle may be reduced to a fibrous band. The **ulnaris digiti quinti** is a rare muscle arising from the dorsal surface of the ulna and inserted into the base of the first phalanx of the little finger. It may be represented by a fasciculus or an extra tendon from the ulnar extensor.

b. DEEP LAYER

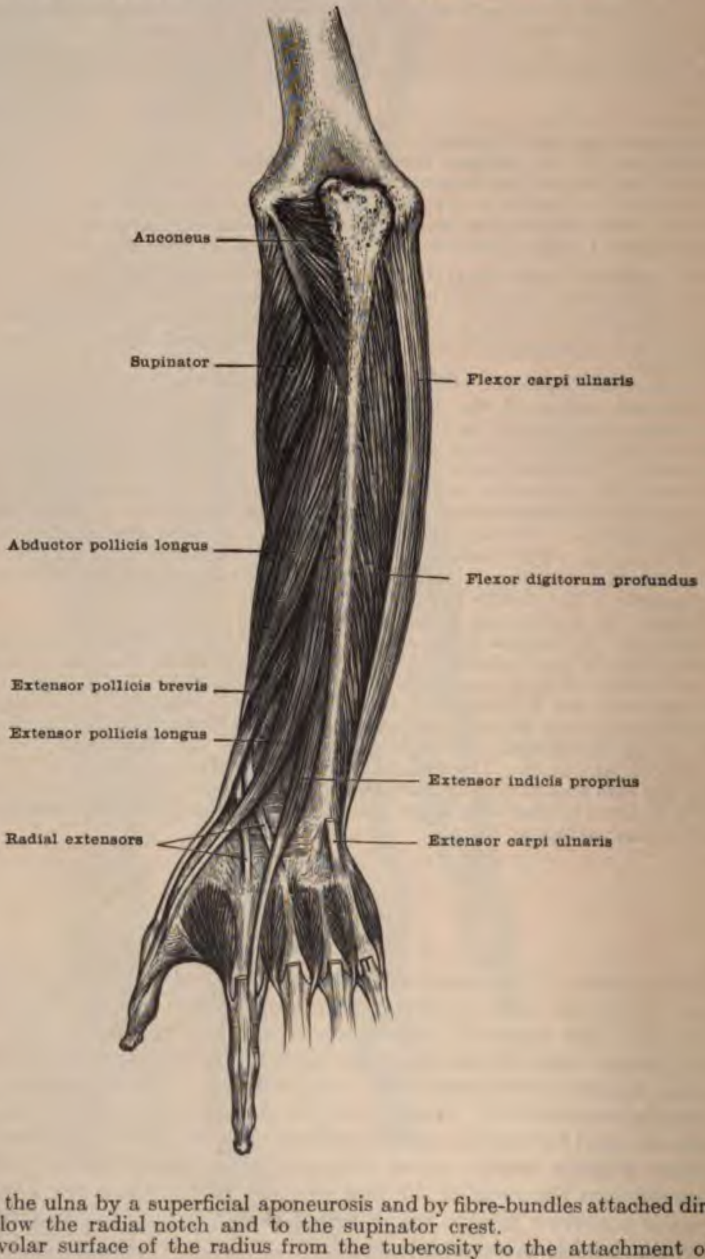
(Fig. 330)

The muscles of this group extend from the ulna to the radius, thumb, and index finger. They are the supinator, abductor pollicis longus, extensor pollicis longus and brevis, and extensor indicis proprius. The **supinator** is a rhomboid muscle which extends from the lateral epicondyle of the humerus and the supinator crest of the ulna around the radius to its volar surface. The **abductor pollicis longus** is a fusiform muscle which arises from the middle third of the ulna, the interosseous membrane, and the radius, and is inserted into the base of the first metacarpal. The **extensor pollicis brevis** arises from the radius distal to the preceding muscle, and is inserted into the base of the first phalanx of the thumb. The **extensor pollicis longus** is a narrow muscle which arises from the middle third of the dorsal surface of the ulna and is inserted into the base of the second phalanx of the thumb. The **extensor indicis proprius** is a narrow, fusiform muscle arising from the shaft of the ulna and inserted into the dorsal aponeurosis of the index finger. These muscles are supplied from branches of the deep radial (posterior interosseous) nerve while this is passing through or after its exit from the supinator.

The extensor pollicis longus is represented by the extensor hallucis longus of the leg. The abductor pollicis longus and extensor pollicis brevis are represented by the abnormal abductor hallucis longus and extensor primi internodii hallucis muscles, the rudiments of which are perhaps normally present in the tibialis anterior. The supinator and the extensor indicis muscles are not represented in the leg. On the other hand, the extensor digitorum brevis, normal in the foot, is only occasionally found on the back of the hand.

The supinator (brevis) (figs. 327 A, 330, 333).—*Origin.*—From (1) the inferior dorsal portion of the lateral epicondyle by a tendinous band which is adherent to the deep surface of the tendons of origin of the radial and common extensors and to the radial collateral ligament of the joint; and (2) the ulna by a superficial aponeurosis and by fibre-bundles attached directly to the depression below the radial notch and to the supinator crest.

FIG. 330.—THE DEEP MUSCLES OF THE BACK OF THE FOREARM.


Anconeus
Supinator
Flexor carpi ulnaris
Abductor pollicis longus
Flexor digitorum profundus
Extensor pollicis brevis
Extensor pollicis longus
Extensor indicis proprius
Radial extensors
Extensor carpi ulnaris

Insertion.—The volar surface of the radius from the tuberosity to the attachment of the pronator teres.

Structure.—From their origin the fibre-bundles descend spirally in a muscular sheet which enwraps the radius (fig. 327 A). The attachment extends to the oblique line. The muscle is divided into a superficial and a deep plane by a septum in which the deep radial (posterior interosseous) nerve runs. The radial attachments of these two portions are separated by an osseous area into which no fibre-bundles are inserted. The fibre-bundles of the superficial layer have a much more vertical course and are longer than those of the deep layer.

Nerve-supply.—By branches which arise from the deep radial (posterior interosseous) nerve as it passes between the two layers of the supinator muscle.

Action.—To supinate the forearm.

Relations.—The supinator is covered by the superficial group of extensor muscles above described and by the anconeus.

Variations.—The extent of separation of the muscles into two portions varies. Accessory fasciculi of origin are not uncommon. These may spring from the annular ligament, **tensor ligamenti annularis anterior** (5 per cent. or more of bodies—Le Double), the lateral epicondyle, the tendon of the biceps, the tuberosity of the radius, etc. A sesamoid bone may lie in the tendon of origin. The **tensor ligamenti annularis posterior** is a slip generally present and often independent of the supinator. It runs from the ulna behind the radial notch to the annular ligament of the radio-ulnar joint.

The abductor pollicis longus (extensor ossis metacarpi pollicis) (fig. 330).—*Origin.*—From (1) the lateral margin of the dorsal surface of the ulna in the proximal portion of the middle third, and the adjacent interosseous membrane, (2) the dorsal surface of the radius distal and medial to the attachment of the supinator, and (3) at times, from the septa lying between it and the supinator, extensor carpi ulnaris, and extensor pollicis longus.

Structure and Insertion.—The fibre-bundles from this extensive area of origin converge in a bipenniform manner upon a tendon which appears as an aponeurosis on the deep surface of the muscle about the middle of the forearm. The tendon as it descends becomes rounded. The insertion of fibre-bundles continues nearly to the wrist. Here, together with the tendon of the short extensor, it enters the first osteo-fibrous canal beneath the dorsal carpal ligament upon the lateral surface of the distal extremity of the radius. Upon leaving this canal the tendon extends to be inserted on the radial side of the base of the first metacarpal bone.

Nerve-supply.—By a branch from the deep radial (posterior interosseous) nerve after it has emerged from the supinator. The branch enters the muscle on the superficial surface in the proximal third.

Action.—It carries the first metacarpal radialwards and forwards. At the height of its contraction it flexes the hand at the wrist. It is a weak supinator of the forearm.

Relations.—Near its origin the muscle is covered by the superficial extensors of the forearm. More distally, accompanied by the short extensor, it passes radially, becomes superficial, and crosses the tendons of the two radial carpal extensors.

Variations.—The muscle or its tendon may be doubled. The accessory tendon may be applied to the multangulum majus (trapezium), the transverse ligament of the carpus, the superficial muscles of the thenar eminence, or the first metacarpal. Of these, the attachment to the short abductor and short flexor is the most frequent (7 out of 36 bodies—Wood). There may be three or more tendons. The muscle may be fused with the short extensor.

The extensor pollicis brevis (fig. 330).—*Origin.*—From the distal part of the middle third of the medial portion of the dorsal surface of the radius and from the neighbouring portion of the interosseous membrane. Rarely its origin extends to the ulna.

Structure and Insertion.—The fibre-bundles are short and converge in a penniform manner on a tendon which appears high on the radial border. The fibres are inserted as far as the dorsal carpal (posterior annular) ligament. The tendon lies parallel to the ulnar side of that of the abductor pollicis longus, and, in close connection with it, passes through the first compartment beneath the dorsal carpal ligament, and crosses the metacarpo-phalangeal joint on the radial side of the long extensor tendon. It is inserted on the base of the first phalanx of the thumb.

Nerve-supply.—From a branch derived from the deep radial (posterior interosseous) nerve. This branch is usually given off in common with or near the nerve to the abductor pollicis longus, and may traverse that muscle to reach the extensor pollicis brevis, which it enters in the proximal third of its radial border.

Action.—To extend the thumb at the metacarpo-phalangeal joint and to abduct the first metacarpal. It likewise acts as a weak supinator of the forearm.

Relations.—It lies between the abductor pollicis longus and the extensor pollicis longus, by which its origin is partly overlapped. In company with the former muscle it passes medially from beneath the common extensor of the fingers and over the tendons of the radial carpal extensors to reach its osteo-fibrous canal under the dorsal carpal ligament.

Variations.—The head of the muscle may be fused with the long abductor. Its tendon of insertion may give rise to a slip inserted on the first metacarpal (in 2 out of 85 bodies—Le Double) or into the terminal phalanx. Its tendon is often united with that of the long extensor. It may be fused with the long abductor of the thumb and has been found missing. It may be doubled.

The extensor pollicis longus (fig. 330).—*Origin.*—From the middle third of the lateral part of the dorsal surface of the ulna; from the neighbouring part of the interosseous membrane; and from the septum between it and the extensor indicis proprius.

Structure and Insertion.—The fibre-bundles converge in a bipenniform manner on the two sides of a tendon which appears high on the dorsal surface of the muscle. They extend as far as the dorsal carpal (posterior annular) ligament. The fusiform body of the muscle descends somewhat obliquely on the dorsal surface of the forearm. The tendon enters the third osteo-fibrous canal beneath the dorsal carpal (posterior annular) ligament. On emerging from the canal it passes very obliquely across the dorsal surface of the carpus, over the tendons of the radial extensors, to the ulnar side of the first metacarpal. It passes along this and on the dorsal surface of the first phalanx, expands to be inserted into the base of the second phalanx.

The aponeurosis of insertion receives tendinous slips from the short muscles of the volar surface of the thumb.

Nerve-supply.—By a twig from the deep radial (posterior interosseous) nerve. The branch gives rise to twigs which enter the proximal third of the radial border of the muscle.

Action.—To extend the second phalanx on the first, and this on the metacarpal. It also draws the whole thumb when extended towards the second metacarpal. It may have a slight supinator action on the forearm.

Relations.—The head of the muscle is partly overlapped by the long abductor of the thumb. It lies between this and the extensor pollicis brevis on one side, and the extensor indicis proprius on the other. Over it lie the extensors of the fingers and the ulnar carpal extensor.

Variations.—The tendon may give a slip to the base of the first phalanx of the thumb, to the dorsal carpal ligament, or to the index finger. It may receive an accessory slip from the common extensor of the fingers or the short extensor of the thumb. It is frequently doubled. An additional extensor is found in about 6 per cent. of bodies between the extensor of the index finger and that of the thumb. It has a double tendon and insertion into both digits (**extensor communis pollicis et indicis**).

The extensor indicis proprius (fig. 330).—*Origin.*—From the proximal part of the distal third of the posterior surface of the ulna, medial and distal to that of the preceding muscle, from the adjacent interosseous membrane, and from the septum between it and the extensor pollicis longus.

Structure and Insertion.—The fibre-bundles pass in penniform manner to be inserted on a tendon which first appears on the radial border of the muscle. The insertion of fibre-bundles extends nearly to the dorsal carpal (posterior annular) ligament. Here the tendon passes beneath that of the extensor of the little finger and enters the fourth osteo-fibrous canal beneath the lateral tendons of the common extensor. It passes across the wrist under and slightly on the ulnar side of the tendon of the index finger, and is inserted on the ulnar side of this into the dorsal aponeurosis of the index finger.

Nerve-supply.—By a twig from the deep radial (posterior interosseous) nerve. This twig enters the proximal third of the radial border of the muscle.

Action.—To extend the first phalanx on the metacarpal. Like the common extensor it has a limited action on the two terminal phalanges. It also serves to adduct the index finger and is a weak supinator of the forearm.

Relations.—It is the most lateral of the deep extensor muscles of the forearm. It is covered by the superficial extensor group.

Variations.—These are frequent. It may be absent. There may be two heads, or the muscle may be completely doubled. It may receive an accessory slip from the ulna or the carpus. The tendon may give accessory slips to the middle finger, the ring finger, or the thumb. The accessory tendon to the middle finger is the most frequent. The tendon to the index finger may be inserted on the metacarpus.

ABNORMAL MUSCLES OF THE BACK OF THE WRIST AND HAND

The **extensor medii digiti** is a small muscle which arises from the ulna beneath the extensor of the index finger, with which it is more or less fused. It sends a tendon to the extensor aponeurosis of the middle finger or slips both to this finger and the index finger. It is present in about 10 per cent. of bodies (Le Double).

The **extensor digiti annularis** is a muscle similar to the extensor medii digiti, but much rarer.

The **extensor digitorum brevis**, which resembles the muscle of corresponding name on the dorsum of the foot, may have from one to four fasciculi, but most frequently one. The most common fasciculus is one which sends a tendon to the extensor tendon of the index finger. One for the middle finger is nearly as frequent. Others are rare. A fasciculus for the thumb has not been reported. (Le Double.) The fasciculi usually arise from the bones of the ulnar half of the carpus—lunatum (semilunar), triquetrum (cuneiform), hamatum (unciform), and capitatum (magnum), and from the dorsal ligaments uniting these bones. The tendons are inserted either into the corresponding extensor tendons or into the metacarpals. The muscle is found in about 10 per cent. of bodies (Wood).

BURSÆ

B. m. extensoris carpi radialis brevis.—Between the tendon and the base of the third metacarpal.

B. m. abductoris pollicis longi.—Between the tendons of the long and short radial extensors and the tendons of the abductor pollicis longus and extensor pollicis brevis. Another bursa lies beneath the tendon of insertion of the abductor.

B. intermetacarpo-phalangeæ.—Between the lateral surfaces of the heads of the metacarpal bones of neighbouring fingers dorsal to the transverse capitular ligament.

B. tendinum m. extensoris digitorum communis.—Small bursæ are sometimes found beneath the tendons to the index and little fingers near where they begin to diverge from the common tendon.

B. m. extensoris carpi ulnaris.—A small bursa may be found under the tendon of origin of this muscle.

B. m. supinatoris.—Between the supinator and the tendon of the extensor muscles.

B. m. extensoris pollicis longi.—Between the tendon and the first metacarpal.

Synovial Tendon-sheaths

Vagina tendinum mm. extensorum carpi radialium.—Synovial sheaths cover the tendons of the two radial carpal extensors as they pass under the dorsal carpal (posterior annular) ligament. In the adult these sheaths usually are more or less fused and communicate with the sheath of the extensor pollicis longus where this crosses them.

Vagina tendinum mm. extensoris digitorum communis et extensoris indicis.—A synovial sheath surrounds the tendons of these muscles as they pass under the dorsal carpal (posterior annular) ligament. This sheath extends for some distance on the tendons as they diverge.

Vagina tendinis m. extensoris digiti quinti.—A synovial sheath extends on the tendon of this muscle from above the dorsal carpal (posterior annular) ligament to the base of the metacarpal.

Vagina tendinis m. extensoris carpi ulnaris.—This sheath commences above the carpal (posterior annular) ligament and extends to the insertion of the tendon.

Vagina tendinum mm. abductoris pollicis longi et extensoris pollicis brevis.—The sheaths which surround these two tendons beneath the dorsal carpal (posterior annular) ligament usually communicate freely.

Vagina tendinis m. extensoris pollicis longi.—A long synovial sheath surrounds this tendon. Where it crosses the tendons of the radial extensors, a communication is found with the sheath of the latter.

2. Volar Group

(Figs. 327, 328, 331–337)

The muscles on the volar side of the forearm lie in four layers.

a. First Layer

(Fig. 331)

Of the four muscles of associated epicondylar origin which constitute this layer the **pronator teres** is a strong, band-like muscle which extends to the lateral surface of the shaft of the radius; the fusiform **flexor carpi radialis** sends a tendon to the base of the second metacarpal; the slender **palmaris longus** is inserted into the palmar fascia; and the medially situated, fusiform **flexor carpi ulnaris** into the pisiform bone and the palmar fascia. The ulnar flexor is supplied by the ulnar nerve, the other muscles by the median.

The pronator teres probably corresponds with the popliteus of the leg. The flexor carpi radialis and flexor carpi ulnaris probably represent in the main the two heads of the gastrocnemius; and the palmaris longus, the plantaris.

The pronator teres (fig. 331).—*Origin.*—By two heads:—(1) The *humeral* or chief head arises by a tendon from the superior half of the ventral surface of the medial epicondyle and directly from the overlying fascia and from the intermuscular septa between it and the medial head of the triceps and the flexor carpi radialis. (2) The *ulnar,* deep or accessory, head arises by an aponeurotic band attached to the inner border of the coronoid process medial to the tendon of the brachialis. Between the humeral and ulnar heads is a fibrous arch beneath which the median nerve passes.

Structure and Insertion.—The fibre-bundles of the humeral head are inserted in a penniform manner on a tendon which begins near the middle of the belly of the muscle on the superficial surface along the radial border. The tendon gradually becomes broader, winds about the volar surface of the radius, and is inserted into the middle third of its lateral surface. The attachment of fibre-bundles continues nearly to this insertion. The fibre-bundles of the ulnar head form a slender fasciculus which is inserted into the radial side of the deep surface of the humeral head.

Nerve-supply.—By a branch derived from the median nerve before it passes between the two heads of the muscle. The nerve enters the proximal part of the middle third of the main belly of the muscle on its deep surface near the radial border. The branch to the ulnar head usually enters this portion of the muscle somewhat proximal to its fusion with the humeral head.

Action.—To pronate and flex the forearm.

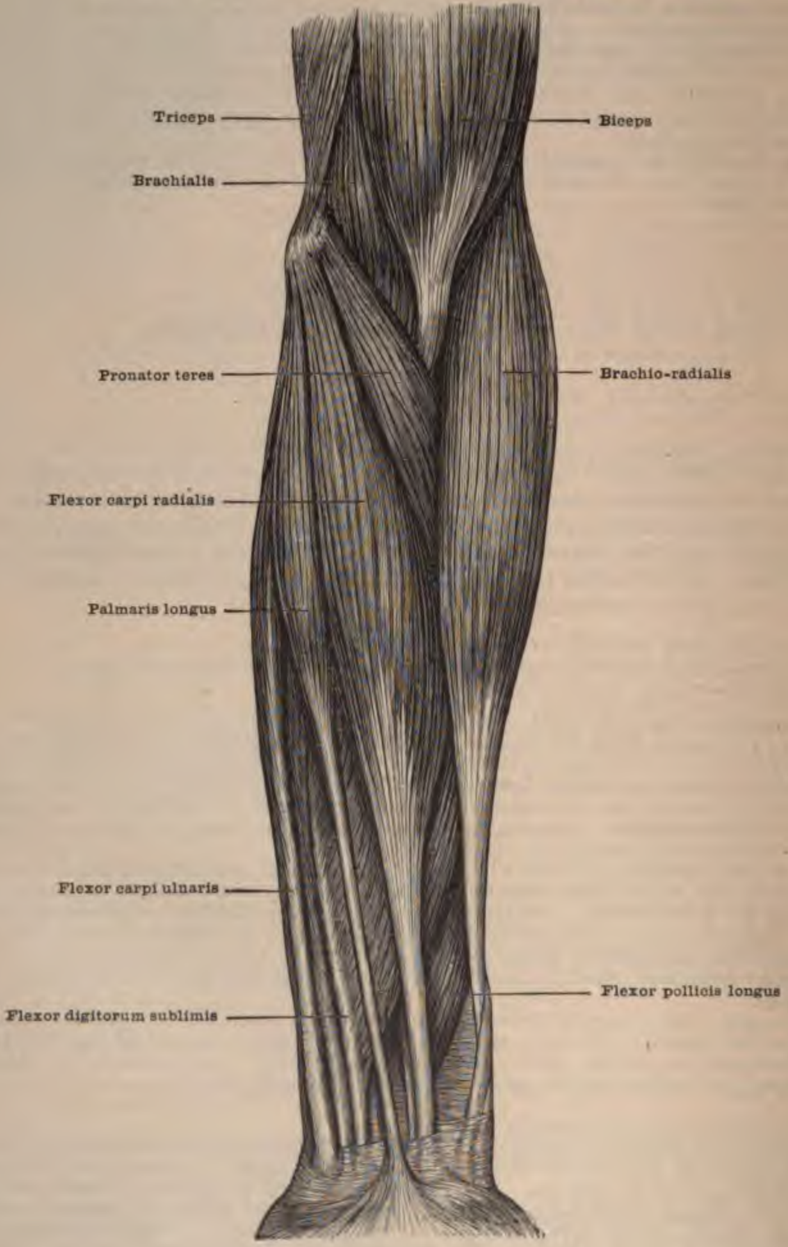
Relations.—The muscle is superficially placed. Near its origin it is covered by the lacertus fibrosus of the biceps, and near its insertion by the radial vessels and nerve and the brachioradialis and radial extensor muscles. It is the most radial of the group of muscles under consideration. The radial border helps to bound an angular space, the cubital fossa, in which lie the brachial vessels, median nerve, and the tendon of the biceps. The median nerve passes between its humeral and ulnar heads. The muscle overlies the supinator, the brachialis, and the radial origin of the flexor digitorum sublimis muscles and the ulnar artery.

Variations.—Supplementary fasciculi may arise from the humerus, the medial intermuscular septum of the arm, the flexor carpi radialis, the flexor sublimis, or the brachialis muscles. The two portions of the muscle may be distinct from origin to insertion. Either part of the muscle may be doubled. The ulnar head may be absent. The radial insertion may be extensive. Fasciculi may extend to the long flexor of the thumb. There may be a sesamoid bone in the tendon of origin from the humerus.

The flexor carpi radialis (fig. 331).—*Origin.*—From (1) the common tendon attached to the medial epicondyle; (2) the septa between its head and the pronator teres, the flexor sublimis, and the palmaris longus; and (3) the fascia of the forearm.

Structure and Insertion.—The fibre-bundles descend to converge upon a tendon at first intramuscular, but which in the middle of the arm appears on the volar surface of the muscle and soon becomes free from the attachment of fibre-bundles. The fibre-bundles from the epicondyle descend nearly vertically to the front and sides of the tendon, while those from the intermuscular septa take an oblique course to the deep surface of the tendon. The tendon is at first flat, but soon becomes cylindrical, bound to the superficial muscle fascia, and enters the hand through a special osteo-fibrous canal formed mainly by the groove in the os multangulum majus (trapezium) and the transverse carpal (anterior annular) ligament. It is inserted into the base of the second metacarpal. It usually also sends a tendon slip to the third.

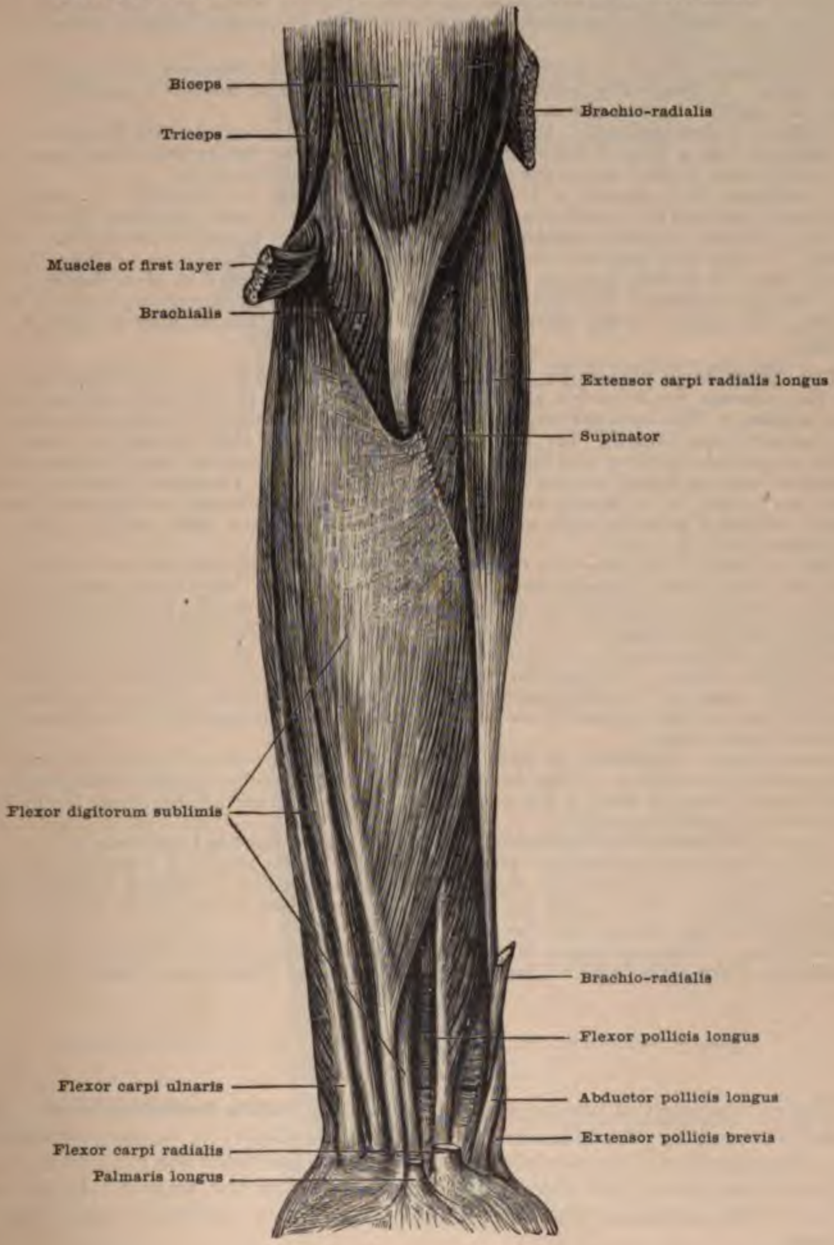
FIG. 331.—FRONT OF THE FOREARM: FIRST LAYER OF MUSCLES.


Triceps
Biceps
Brachialis
Pronator teres
Brachio-radialis
Flexor carpi radialis
Palmaris longus
Flexor carpi ulnaris
Flexor pollicis longus
Flexor digitorum sublimis

Nerve-supply.—By a branch from the median nerve which divides into several twigs that enter the muscle near the junction of its proximal and middle thirds on the deep surface. The nerve usually arises near the elbow in conjunction with that to the palmaris longus and near that to the pronator teres.

Action.—To flex the hand at the wrist. To a slight extent it may also act as a pronator of the forearm and a flexor of the forearm on the arm. It is also said to be an abductor of the hand, but this has been denied by Duchenne.

Fig. 332.—Front of the Forearm: Second Layer of Muscles.


Biceps
Triceps
Brachio-radialis
Muscles of first layer
Brachialis
Extensor carpi radialis longus
Supinator
Flexor digitorum sublimis
Brachio-radialis
Flexor pollicis longus
Flexor carpi ulnaris
Abductor pollicis longus
Extensor pollicis brevis
Flexor carpi radialis
Palmaris longus

Relations.—It is superficial except near its insertion. The belly of the muscle lies between the pronator teres and the palmaris longus and upon the flexor digitorum sublimis. The tendon of the muscle passes over the flexor pollicis longus, and near the wrist is a guide to the radial artery, which here lies lateral to it. In the hand the tendon lies beneath the thenar muscles and is crossed by the tendon of the long flexor of the thumb.

Variations.—It may receive a fasciculus from the brachialis or biceps muscles or from the radius or ulna. It may send tendon slips to the multangulum majus (trapezium), navicular, the transverse carpal (anterior annular) ligament, or the fourth metacarpal. The insertion may take place variously into these structures.

The palmaris longus (fig. 331).—*Origin.*—From the common tendon attached to the medial epicondyle and from the surrounding intermuscular septa and the fascia of the arm.

Structure and Insertion.—The fibre-bundles take a nearly parallel course to a tendon which appears high in the middle third of the forearm on the volar surface of the muscle. In the middle of the forearm the attachment of fibre-bundles usually ceases, the tendon becomes bound to the overlying fascia, and descends parallel with that of the radial flexor. Near the proximal border of the transverse carpal (anterior annular) ligament the tendon expands into radiating bundles of fibres of which the medial and lateral are attached to the fascia over the intrinsic muscles of the thumb and little finger, while the middle, much more developed, constitute the chief portion of the palmar aponeurosis.

Nerve-supply.—From a branch which usually arises in company with the nerve to the radial flexor. It frequently traverses the superficial fibres of the flexor sublimis. The nerve enters the middle third of the muscle.

Action.—To flex the hand. It is also a weak flexor and pronator of the forearm.

Relations.—It is placed between the radial and ulnar flexors over the flexor sublimis. In the distal part of the forearm the tendon lies over the median nerve.

Variations.—It is absent in 11.2 per cent. of instances (Le Double). It may be highly developed or reduced to a tendinous band. The belly of the muscle may lie in the distal instead of in the proximal part of the forearm. It may be digastric It may be fused with neighbouring muscles. It may arise from the medial intermuscular septum of the arm or from the lacertus fibrosus, from the radius, from the coronoid process, from the radial or ulnar flexor, or from the flexor sublimis muscles. The tendon may terminate in the fascia of the forearm, the thenar eminence, the carpus, or the abductor of the thumb. The muscle may be partly or wholly doubled.

The flexor carpi ulnaris (fig. 331).—*Origin.*—By two heads:—(1) the **humeral head** arises from the common flexor tendon attached to the lower ventral part of the medial epicondyle. Fibre-bundles of this head are also attached to the surrounding intermuscular septa and the deep fascia of the forearm. (2) The **ulnar head** arises by short tendinous fibres from the medial side of the olecranon and by an aponeurotic band common to it and the flexor digitorum profundus from the upper two-thirds of the crest of the ulna. Proximally the two heads of the muscle are united by a fibrous arch extending from the olecranon to the medial epicondyle. Beneath this band pass the ulnar nerve and the dorsal recurrent ulnar artery. (See EPITROCHLEO-OLECRANONIS, p. 392.)

Structure and Insertion.—The fibre-bundles of the humeral head descend nearly vertically, those of the ulnar head obliquely distally in a radial direction. They are inserted in a penniform manner on a tendon which appears in the proximal part of the middle third of the belly of the muscle on the radial margin of the deep surface, and in the distal third of the forearm forms the radial border of the muscle. On the ulnar side the insertion of fibre-bundles continues nearly to the pisiform bone. The insertion of the tendon takes place chiefly into the pisiform bone, but from it tendinous bundles extend to the palmar aponeurosis, to the pisohamate ligament (pisi-unciform), to the surface of the abductor of the little finger, and to the bases of the fifth and fourth metacarpals.

Nerve-supply.—From two or three branches of the ulnar nerve, the most proximal of which arises near the elbow-joint. These branches, which may arise by a single trunk, enter the deep surface of the proximal third of the muscle and send long twigs distally across the middle third of the constituent fibre-bundles.

Action.—To flex the hand and rotate the lateral side of the hand volarwards.

Relations.—It is superficially placed. Its aponeurotic origin is adherent to the fascia of the forearm. It lies medial to the palmaris longus and flexor sublimis and upon the flexor profundus. Beneath the muscle lies the ulnar nerve. The ulnar artery extends along the radial border of the tendon near the wrist.

Variations.—These are rare. Slips from the tendon may pass to the metacarpo-phalangeal articulation of the little finger. (See, however, ABNORMAL MUSCLES, p. 392.)

b. SECOND LAYER

This is composed of one muscle, the **flexor digitorum sublimis,** which, although in part covered by the muscles of the preceding layer, is in part superficial. It arises from the medial epicondyle of the humerus, and from the radius and the ulna, and sends tendons to the second row of phalanges of the fingers. It corresponds probably with the soleus and the tendons of the flexor digitorum brevis in the leg and foot.

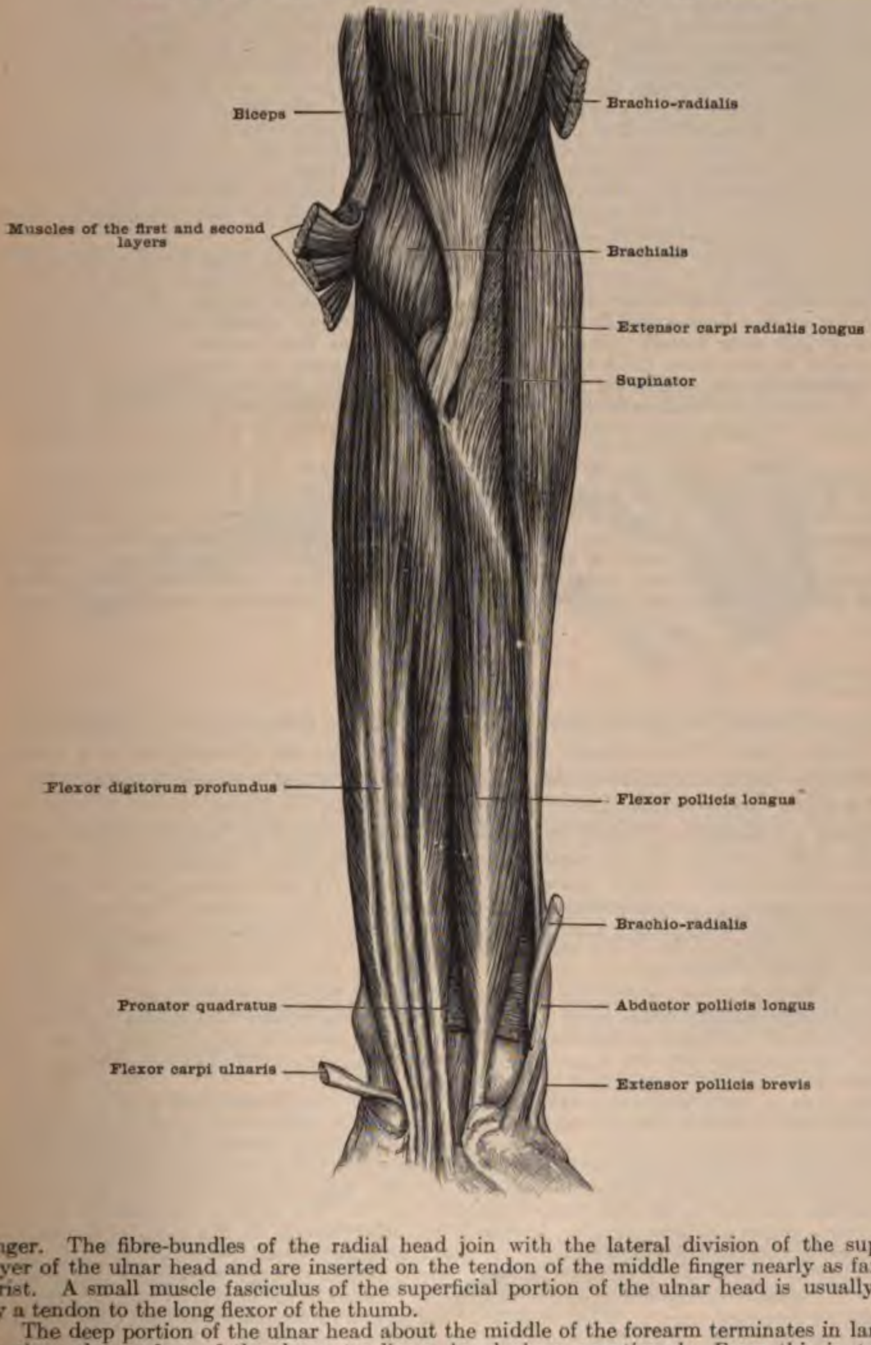
The flexor digitorum sublimis (figs. 332, 334, 337).—*Origin.*—By two heads: the **ulnar or chief head** arises (1) by the tendon common to it and the superficial group of muscles from the medial epicondyle, and by short tendinous bands from the ventral surface of the epicondyle; (2) from the ulnar collateral ligament of the elbow, the ulnar tuberosity, the medial border of the coronoid process, and the inferior extremity of the tendon of the brachialis; and (3) from the intermuscular septum between the flexor sublimis and the overlying muscles. The **radial head** arises from an oblique line on the volar surface of the radius, and from the middle third of the anterior border.

Insertion.—Into the sides of the shafts of the second row of phalanges of the fingers.

Structure.—The fibre-bundles of the ulnar head and the upper part of the radial head converge, the ulnar fibre-bundles nearly vertically, the radial obliquely, to form a common belly the deep surface of which on the ulnar side is backed by a dense tendinous band. On the radial side of this a less dense membrane covers over an oval canal which passes distally along the line of junction of the two heads and lodges the ulnar artery and the median nerve.

The fibre-bundles of the ulnar head form a superficial and a deep group. The superficial portion near the middle of the forearm divides into a lateral and a medial division, the former being inserted on a tendon that goes to the middle and the latter on one that goes to the ring finger. The fibre-bundles of the radial head join with the lateral division of the superficial layer of the ulnar head and are inserted on the tendon of the middle finger nearly as far as the wrist. A small muscle fasciculus of the superficial portion of the ulnar head is usually united by a tendon to the long flexor of the thumb.

FIG. 333.—FRONT OF THE FOREARM: THIRD LAYER OF MUSCLES.


Biceps
Brachio-radialis
Muscles of the first and second layers
Brachialis
Extensor carpi radialis longus
Supinator
Flexor digitorum profundus
Flexor pollicis longus
Brachio-radialis
Pronator quadratus
Abductor pollicis longus
Flexor carpi ulnaris
Extensor pollicis brevis

The deep portion of the ulnar head about the middle of the forearm terminates in large part on the volar surface of the dense tendinous band above mentioned. From this in turn two muscle bellies arise. One of these is inserted in a bipenniform manner on a tendon going to the index finger, the other on a tendon going to the little finger. A muscle fasciculus also usually passes from the region of the tendon band to that portion of the superficial fasciculus which terminates on the tendon of the ring finger.

The four tendons pass together through the carpal canal under the transverse carpal (anterior annular) ligament, those to the middle and ring fingers lying at first superficial to the other two. The tendons then diverge, and each tendon, together with and above a tendon of the flexor profundus, passes over the metacarpo-phalangeal joint into an osteo-fibrous canal on the palmar surface of the first phalanx of the finger for which it is destined. Here the tendon becomes flattened about the round tendon of the flexor profundus. Opposite the middle of the phalanx the tendon divides into two slips, between which the tendon of the flexor profundus passes. The divided halves of the sublimis tendon fold about the profundus tendon so that their lateral edges come to meet in the mid-line beneath this tendon opposite the phalangeal joint (figs. 336, 337). They then again separate, extend distally, and are attached one on each side into a ridge at the middle of the lateral border of the second phalanx. The tendons are also attached by **vincula tendinum,** a **ligamentum breve,** between the tendon and the head of the first phalanx and the joint, and a **ligamentum longum,** between the tendon and the volar surface of the first phalanx.

Nerve-supply.—Before the median nerve passes between the two heads of the pronator teres a branch arises which accompanies the nerve through the pronator and sends several branches into the proximal third of the ulnar head of the muscle. As the median nerve passes beneath the muscle, one or more branches are given to the radial head, and a long branch is given to the fasciculus of the second and one to that of the fifth digit. Occasionally, it is said, the median nerve in the distal third of the forearm gives rise to branches for these fasciculi

Action.—Chiefly to flex the second phalanx of each finger on the first; secondarily, to flex the fingers on the hand and the hand on the forearm.

Relations.—The belly of the muscle is covered by the pronator teres, flexor carpi radialis, and palmaris longus, but is superficial along a narrow strip between the flexor carpi ulnaris and the palmaris longus, and on each side of the tendon of the flexor carpi radialis. The muscle rests on the flexor pollicis longus and flexor digitorum profundus, the median nerve (see description given above) and ulnar vessels. The median nerve emerges from beneath the radial border of the muscle in the lower third of the forearm. In the palm the tendons lie beneath the palmar aponeurosis, the superficial palmar arch, and the branches of the median nerve, while they lie in front of the tendons of the flexor profundus, with which they are closely associated into a common bundle by loose fibrous tissue. The digital relations of the tendons are described above.

Variations.—The whole muscle may be rendered digastric by a transverse tendon. A fasciculus of the flexor sublimis may replace the palmaris longus or the two may coexist. A fasciculus may terminate in the fascia of the forearm or in the transverse carpal ligament, the palmar aponeurosis, etc. Various parts of the muscle may be absent or more independent than usual. The extent of the radial attachment varies greatly and may be missing. A special fasciculus may be received from the coronoid process of the ulna. A fasciculus may be sent to the flexor profundus or to other muscles. There may be some fusion with neighbouring muscles.

c. THIRD LAYER

(Figs. 333–337)

The two muscles which constitute this layer may be looked upon as differentiated from a single deep flexor muscle. The **flexor digitorum profundus** is a strong, broad muscle which arises from the upper three-fourths of the volar surface of the ulna and gives rise to tendons which are inserted into the bases of the third row of phalanges of the fingers. The **flexor pollicis longus,** likewise broad and flat, arises from the volar surface of the radius and is inserted into the base of the second phalanx of the thumb. Both muscles are supplied by the median nerve and the flexor profundus is also supplied by the ulnar nerve.

These muscles correspond respectively to the flexor digitorum longus and flexor hallucis longus of the leg.

The flexor digitorum profundus (figs. 333, 337).—*Origin.*—(1) Through an aponeurotic septum between it and the flexor carpi ulnaris from the dorsal border of the ulna; (2) directly from the proximal two-thirds of the medial surface and the proximal three-fourths of the volar surface of the ulna and from the adjacent interosseous membrane; and (3) inconstantly, from a small area on the radius below the bicipital tuberosity.

Structure and Insertion.—The fibre-bundles descend nearly vertically and give rise to a common belly which soon divides into four portions, each of which is attached about midway down the forearm in a semipenniform manner to the dorsal surface of a tendon. The attachment of fibre-bundles continues nearly to the wrist. The digital divisions of the muscle vary in the height to which they extend. That belonging to the index finger is usually the one most extensively isolated, and that to the little finger is the next most so. The tendons pass side by side under the transverse carpal (anterior annular) ligament, and then diverge to the bases of the fingers. At the metacarpo-phalangeal joints, they enter the osteo-fibrous canals described above (p. 376). On the volar surface of the first phalanx each tendon passes through the slit in the sublimis tendon. The tendon then is continued over the second phalanx to the base of the third. **Vincula tendinum** are described passing to the capsule of the second interphalangeal joint (**ligamentum breve**) and to the tendon of the flexor sublimis (**ligamentum longum**). The lumbrical muscles arise from the tendons while they are in the palm.

Nerve-supply.—The interosseous branch of the median nerve arises usually before the nerve passes through the pronator teres and accompanies the main trunk. This branch as it passes beneath the flexor sublimis gives off a branch (or two) from which several twigs spring.

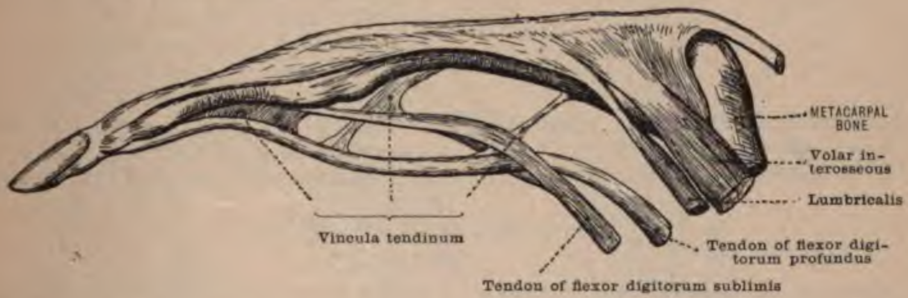
These twigs enter the muscle near the radial border and pass in across the middle third of the constituent fibre-bundles of the fasciculi to the index and middle fingers. The ulnar nerve near the elbow gives rise to a branch which enters the volar surface of the muscle near the junction of the proximal and middle thirds of that portion of the belly, giving tendons to the ring and little fingers. There is some variation in the extent of the innervation by the branches of the ulnar and those of the median nerve. To a greater or less extent through anastomosis their territories overlap.

Action.—To flex the terminal phalanx of each finger on the second and the second on the first, while that of the superficial flexor is to flex the second phalanx on the first. The action of the two flexors on the first phalanx is somewhat more limited. The interosseous muscles, aided by the lumbricals, are the chief flexors of the first row of phalanges. The flexor profundus acts, though not powerfully, as a flexor of the wrist.

Relations.—The flexor profundus muscle lies beneath the flexor sublimis and the flexor carpi ulnaris muscles, the median nerve, and the ulnar vessels and nerve. Under the muscle lie the ulna, the interosseous membrane, and the pronator quadratus muscle. Under the transverse carpal (anterior annular) ligament the tendons lie beneath those of the flexor sublimis in the same synovial sac. In the palm the tendons with the associated lumbrical muscles lie upon the interosseous muscles, the adductor of the thumb, and the deep palmar arch, and beneath the flexor sublimis tendons. For the relations to the synovial bursæ see p. 393.

Variations.—There is considerable variation in the extent of the radial origin and in the extent of the independence and fusion of the different fasciculi. In the prosimians a common tendon extends as far as the hand. The division in the higher forms is associated with refinement of movements of the fingers. One or more special fasciculi not infrequently join the muscle from the flexor sublimis, the flexor pollicis longus, the medial epicondyle, or the ulna. The **accessorius ad flexorem digitorum profundum** is a fasciculus which arises from the coronoid process of the ulna and sends a tendon to join the tendon of one of the fingers, most frequently the middle or index. It is found in 20 per cent. of bodies.

FIG. 334.—INSERTIONS OF THE TENDONS OF THE MUSCLES WHICH ACT ON THE FINGER. (After Toldt, Atlas of Human Anatomy, Rebman, London and New York.)


METACARPAL BONE
Volar interosseous
Lumbricalis
Vincula tendinum
Tendon of flexor digitorum profundus
Tendon of flexor digitorum sublimis

The flexor pollicis longus (fig. 333).—*Origin.*—The attachment extends along the oblique line and the ventral border of the radius from slightly below the bicipital tuberosity to within 5 cm. of the wrist. Medially it is continued into the interosseous membrane. Proximally the tendon frequently descends from the distal radial margin of the coronoid process of the ulna to give rise to fibre-bundles connected with the muscle, as well as to a fasciculus of the flexor profundus.

Structure and Insertion.—The fibre-bundles descend obliquely to be inserted in a penniform manner on a tendon which begins high up on the volar surface near the ulnar border of the muscle, and descends as a broad band which near the wrist becomes cylindroid. The insertion of fibres continues nearly to the point where the tendon passes under the transverse carpal ligament. Here the tendon enters the carpal canal lateral to the tendons of the flexor profundus, and passes beneath the superficial head of the short flexor of the thumb, then between the thumb sesamoids into the osteo-fibrous canal of the thumb, in which it is continued to the base of the terminal phalanx.

Nerve-supply.—Usually from two branches of the volar interosseous ramus of the median nerve. These enter the proximal half of the ulnar margin of the muscle.

Action.—It is a strong flexor of the second phalanx on the first and has less powerful action on the metacarpo-phalangeal joint and on the wrist.

Relations.—It lies under the flexor sublimis, the flexor carpi radialis and brachio-radialis muscles, and the radial artery. Near the wrist it crosses over the insertion of the pronator quadratus. In the hand the tendon runs beneath the opponens pollicis and the superficial head of the flexor brevis, and across the deep head of the latter.

Variations.—It may be fused or united by fasciculi with the flexor profundus, the flexor sublimis, or the pronator teres. It may be partially doubled, giving rise to an accessory tendon which extends to the index finger. The radial origin is inconstant. The origin may extend to the medial epicondyle of the humerus (epitrochlear bundle).

d. FOURTH LAYER

This layer consists of a single quadrilateral muscle which passes transversely across the lower part of the forearm from the ulna to the radius. In the leg there is no corresponding muscle.

The pronator quadratus (fig. 338).—*Origin.*—Medial side of the volar surface of the lower fourth of the ulna.

Structure and Insertion.—From the ulna a strong aponeurosis extends a third of the way across the volar surface of the muscle. From this membrane and from the bone fibre-bundles extend transversely to be inserted on the distal quarter of the volar surface of the radius and on the triangular area above the ulnar notch. The deeper fibre-bundles which arise directly from the ulna are inserted into the radius by means of an aponeurosis. The superficial and deep portions of the muscle are often separated. The muscle is thicker distally than proximally.

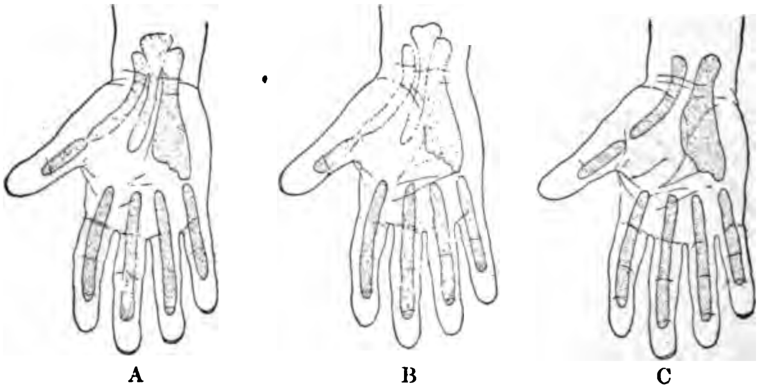
Nerve-supply.—The volar interosseous nerve descends along the interosseous membrane, passes behind the middle of the proximal margin of the muscle, and sends branches into its deep surface.

Action.—To pronate the forearm.

Relations.—The muscle lies immediately beneath the muscles of the third layer and upon the radius and ulna, the interosseous membrane, and radio-ulnar joint. The radial artery and ulnar nerve pass in front of it, the volar interosseous artery behind it.

Variations.—It may be missing or may extend further up the forearm than usual or down upon the carpus. It may be triangular or divided into parts the fibre-bundles of which take different directions. It may send fasciculi to the carpus or metacarpus or be fused with the flexor carpi radialis brevis (see below).

FIG. 335.—SYNOVIAL SHEATHS OF THE TENDONS OF THE LONG FLEXORS OF THE FINGERS.
A. Frequent type; B. normal type; C. fœtal type. (After Poirier and Charpy.)



ABNORMAL MUSCLES OF THE VOLAR SIDE OF THE FOREARM AND WRIST

The epitrochleo-olecranonis (anconeus internus).—A muscle fasciculus, distinct from the distal margin of the triceps, which runs from the medial epicondyle to the olecranon over the groove for the ulnar nerve, by a branch of which it is supplied. It takes the place of the fibrous arch normally extending between the epicondylar and ulnar heads of the flexor carpi ulnaris. It occurs in about 25 per cent of bodies (Testut), and represents an adductor of the olecranon of the lower mammals. Occasionally the medial head of the triceps may descend over the ulnar groove, but this forms another type of muscle variation.

The flexor carpi ulnaris brevis (ulno-carpeus).—An abnormal muscle which arises from the distal quarter of the volar surface of the ulna and is inserted into the hamatum (unciform), the pisiform, the abductor of the little finger, or the superior extremity of the fifth metacarpal.

The unci-pisiformis.—A short, thick band of muscle which runs from the pisiform to the tip of the hamulus of the os hamatum (unciform) parallel with the pisohamate (pisi-unciform) ligament. It is innervated by the ulnar nerve.

The flexor carpi radialis brevis (radio-carpeus).—An abnormal muscle found in about 5 per cent. of bodies (Le Double). It arises from the lateral or the volar surface of the distal half of the radius. Some of the fibre-bundles may spring from the pronator quadratus, the fascia of the forearm, or the ulna. It is inserted into the carpus or metacarpus, and occasionally even into the first phalanx of the index finger, etc. It is supplied by a branch of the volar interosseous nerve. It serves to flex the wrist. It is said to represent the tibialis posterior of the leg.

BURSÆ

B. m. flexoris carpi ulnaris.—Between the tendon of this muscle and the pisiform bone.

B. m. flexoris carpi radialis.—Between the tendon of this muscle and the tubercle of the navicular bone.

A bursa is often found between the tendon of the deep flexor of the index finger and the carpus. This bursa is frequently in communication with the radial and ulnar tendon sheaths.

A bursa is also often found between the deep and superficial tendons of the index finger.

Synovial Tendon Sheaths

(Figs. 327 and 335)

Vagina tendinis m. flexoris carpi radialis.—About the tendon as it passes beneath the transverse carpal ligament.

Vaginæ tendinum mm. flexorum digitorum.—The osteo-fibrous canals of the digits are lined by a synovial membrane which is reflected by means of a fold (cul-de-sac) to the tendons at each end and over the vincula tendinum, in which blood-vessels and nerves for the tendons are contained. The synovial cavity of the first and usually that of the fifth digit communicate with those of the palm.

In the wrist and palm two large synovial sacs may usually be recognized, although the number may be raised to five or reduced to one.

The radial sac, **vagina tendinis m. flexoris pollicis longi,** surrounds the long flexor tendon of the thumb in the wrist and palm and usually communicates with that of the thumb. In the palm a well-marked mesotendon usually extends to the deep ulnar side of the tendon from the parietal layer of the sheath.

The ulnar sac, **vagina tendinum mm. flexorum communium,** surrounds the tendons of the long flexors of the fingers. It begins proximal to the transverse carpal ligament and extends nearly or quite to the synovial sheath of the little finger on the ulnar side and on the radial side to the centre of the palm.

3. Musculature of the Hand

(Figs. 327, 329, 336–338, 340)

The intrinsic muscles of the hand are taken up in the following groups:—

a The subcutaneous muscle of the palm.
b The muscles of the little finger.
c The muscles of the thumb.
d The lumbrical muscles.
e The interosseous muscles.

The ulnar nerve supplies the muscles of the little finger, the interossei, the medial lumbrical muscles, and some of the muscles of the thumb; the median nerve supplies most of the muscles of the thenar region and the lateral lumbrical muscles.

(*a*) Subcutaneous Muscle

(Fig. 336)

The **palmaris brevis** is a small, trapezoid sheet situated between the hypothenar fascia and the skin. It arises at the lateral edge of the palmar aponeurosis from tendinous slips which may be traced through the aponeurosis to the navicular and greater multangular. It is composed of nearly parallel fibre-bundles, and extends into the deep surface of the skin along the ulnar border of the palm. It is generally taken to be a subcutaneous muscle like the superficial muscles of the head and neck. It has, however, been suggested that it represents the remnants of a short flexor of the digits corresponding with the flexor digitorum brevis of the foot.

Nerve-supply.—The superficial branch of the palmar division of the ulnar nerve gives rise to a twig which enters the deep surface of the muscle.

Action.—The action of the muscle is to draw the skin of the ulnar side of the hand towards the centre of the palm. It is said that it thus helps to form a cup-shaped hollow when the hand conveys fluid to the mouth. The contraction of the muscle by raising a ridge over the ulnar nerve and artery when an object is grasped hard serves, according to Henle, to protect these structures.

Variations.—It varies in size. In about 2 per cent. of bodies it is absent (Le Double). It may send tendinous slips to the pisiform bone. (For a thenar subcutaneous muscle, see variations of the abductor pollicis brevis.)

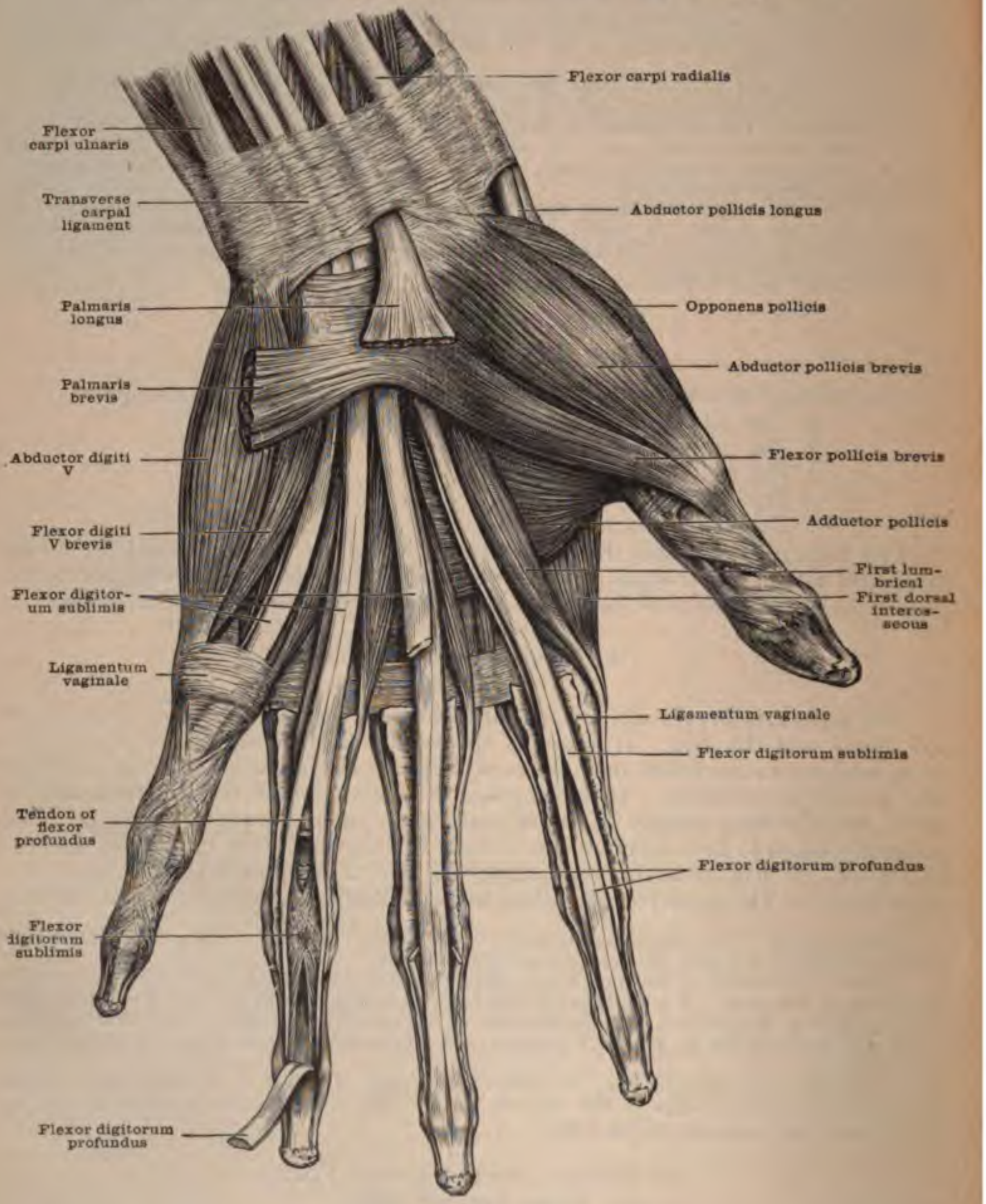
(*b*) Muscles of the Little Finger

(Figs. 336, 337, 338)

In the hypothenar eminence are three muscles, the abductor, the flexor brevis, and the opponens digiti quinti. The **abductor digiti quinti** is a flat, fusiform muscle which extends from the pisiform to the ulnar border of the first phalanx. The fusiform **flexor brevis** extends from the hamatum (unciform) and adjacent part of the transverse carpal (anterior annular) ligament to the ulnar side of the base of the first phalanx. The triangular **opponens** likewise arises from the hamatum (unciform) and the transverse (anterior annular) ligament. It is inserted into the ulnar border and the head of the fifth metacarpal.

The abductor of the little finger corresponds with that of the little toe. A part of the opponens beneath the ulnar nerve corresponds with that of the little toe, while the more superficial portion is unrepresented. The flexor brevis of the little toe corresponds with a part of the deep portion of the opponens of the little finger. The flexor brevis of the little finger is unrepresented in the foot. (Cunningham.)

FIG. 336.—THE SUPERFICIAL MUSCLES OF THE PALM OF THE HAND.


Flexor carpi radialis
Flexor carpi ulnaris
Transverse carpal ligament
Abductor pollicis longus
Palmaris longus
Opponens pollicis
Abductor pollicis brevis
Palmaris brevis
Abductor digiti V
Flexor pollicis brevis
Adductor pollicis
Flexor digiti V brevis
First lumbrical
First dorsal interosseous
Flexor digitorum sublimis
Ligamentum vaginale
Ligamentum vaginale
Flexor digitorum sublimis
Tendon of flexor profundus
Flexor digitorum profundus
Flexor digitorum sublimis
Flexor digitorum profundus

The abductor digiti quinti (figs. 336, 337).—*Origin.*—From the distal half of the pisiform, the ligaments between this and the hamatum, the tendon of the flexor carpi ulnaris, and often from the transverse carpal (anterior annular) ligament.

Structure and Insertion.—The fibre-bundles descend vertically, at first increasing in number and then concentrated, towards two short tendons one of which is inserted into the ulnar border of the first phalanx of the little finger and the other into the aponeurosis of the extensor tendon of the little finger.

Nerve-supply.—From the deep palmar division of the ulnar nerve before it passes through the opponens, or from the superficial palmar branch, arises a twig which enters the radial side of the muscle on its deep surface in the proximal third.

Action.—To abduct the little finger, flex the first phalanx, and extend the last two.

Relations.—It overlies the opponens and flexor brevis. Superficially it is covered by fascia and the palmaris brevis muscle. Along the proximal part of its radial margin run the deep palmar branches of the ulnar artery and nerve.

Variations.—It may be missing or doubled. It may be fused with the short flexor or receive fasciculi from the palmaris longus, the ulnar flexor, the fascia of the forearm, etc.

The flexor digiti quinti brevis (figs. 337, 338).—*Origin.*—By a short tendon from the hook of the hamatum (unciform) and from the adjacent parts of the transverse carpal (anterior annular) ligament.

Structure and Insertion.—The fibre-bundles take a nearly parallel course and are inserted by a short tendon which is fused with that of the abductor and is inserted into the ulnar side of the base of the first phalanx of the little finger. A sesamoid bone may lie in the tendon.

Nerve-supply.—A branch from the superficial or deep palmar division of the ulnar nerve enters the deep surface of the muscle in its proximal half. The nerves to the abductor and flexor may arise in common from the ulnar.

Action.—To flex the first phalanx of the little finger. When it sends a tendon slip to the aponeurosis of the extensor of the finger it helps to extend the two terminal phalanges.

Relations.—The muscle closely adjoins and is partly covered by the abductor. The palmaris brevis and the lateral volar digital artery to the fifth finger lie superficial to it. Under it lies the opponens.

Variations.—The muscle may be wanting or may be closely fused with the abductor or the opponens. It may receive an accessory slip from the forearm fascia. It may give a tendon slip to the extensor aponeurosis or to the head of the fifth metacarpal.

The opponens digiti quinti (fig. 338).—*Origin.*—Partly tendinous, from the distal ulnar border of the hook of the hamatum (unciform) and from the adjacent transverse carpal (anterior annular) ligament.

Structure and Insertion.—The fibre-bundles diverge, the proximal short and horizontal, the distal long and oblique, and are inserted on the whole of the ulnar border and on a part of the head of the fifth metacarpal. Often the muscle is divisible into two portions between which the ulnar nerve runs.

Nerve-supply.—Before the deep palmar branch passes through the muscle it gives rise to a twig which enters its volar surface in the middle third near the ulnar margin.

Action.—To flex, adduct, and slightly rotate the fifth metacarpal; as, for example, in 'cupping' the hand to drink from it.

Relations.—The opponens lies below the abductor and flexor brevis muscles. The deep branches of the ulnar nerve and artery pass through the opponens near its carpal origin and then under it extend into the palm.

Variations.—It may be fused with neighbouring muscles or receive accessory slips.

The tensor capsularis articulationis metacarpo-phalangei digiti quinti is a slender muscle which arises from the ligaments which unite the pisiform to the hamatum, and is inserted into the volar surface of the metacarpo-phalangeal joint of the little finger.

(c) Muscles of the Thumb

(Figs. 336, 337, 338)

In the thenar region there are four muscles. Of these, the abductor pollicis brevis is the most superficial. Then come the opponens pollicis and the short flexor, and beneath the last the adductor pollicis. All are triangular in form. The **abductor pollicis brevis** extends from the carpus to the radial side of the first phalanx of the thumb. The **opponens** is a thick muscle extending from the transverse carpal (anterior annular) ligament to the radial side of the first metacarpal. The **flexor pollicis brevis** extends from the carpus to the radial side of the base of the first phalanx. The **adductor pollicis** extends from the carpus and the second and third metacarpals to the ulnar side of the first phalanx of the thumb.

In the foot an opponens hallucis occurs as an abnormal muscle. The abductor, flexor brevis and adductor of the thumb are represented by the corresponding muscles of the big toe, although the last two muscles are not perfectly homologous in the hand and foot.

The abductor pollicis brevis (fig. 336).—*Origin.*—From the volar surface of the transverse carpal (anterior annular) ligament, and from the greater multangular bone (trapezium). Also often from the navicular bone and from a tendon slip of the long abductor.

Structure and Insertion.—The fibre-bundles converge upon a flat tendon with two lamellæ, the deeper of which is inserted into the radial side of the base of the first phalanx of the thumb and the superficial into the aponeurosis of the extensor pollicis longus.

Nerve-supply.—By a branch of the first volar digital ramus of the median nerve. This branch passes over or through the flexor brevis and enters the muscle on the volar surface at the junction of the proximal and middle thirds near its ulnar border.

Action.—To abduct the thumb, flex the first phalanx, and extend the terminal phalanx.

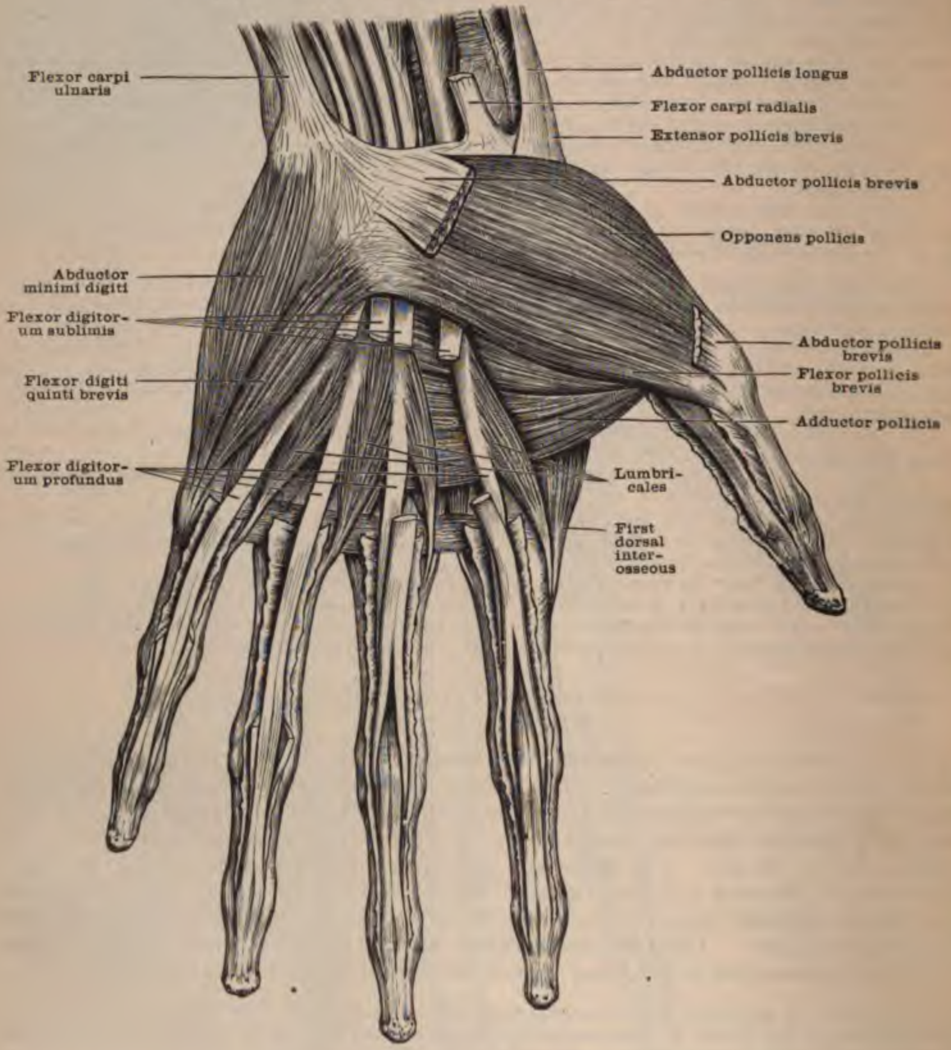
Relations.—It lies beneath the thenar fascia lateral to the superficial head of the flexor brevis and over the opponens. The superficial volar artery usually perforates the muscle.

Variations.—It may be wanting or may be divided into two divisions. The origin may extend to the fascia of the forearm or styloid process of the radius. It may receive an accessory slip from the long radial extensor, the opponens, or the short extensor of the thumb. A *thenar subcutaneous muscle* is occasionally present. It is narrow, is closely associated with the short abductor of the thumb, and extends from the radial side of the base of the first metacarpal into the skin of the thenar eminence.

The opponens pollicis (fig. 338).—*Origin.*—From the volar surface of the transverse carpal (anterior annular) ligament and from the tubercle of the greater multangular bone (trapezium).

Structure and Insertion.—The fibre-bundles extend obliquely in a nearly parallel direction to their insertion along the whole lateral border of the volar surface of the shaft and the head of the first metacarpal.

Fig. 337.—The Deeper Muscles of the Palm of the Hand.


Flexor carpi ulnaris
Abductor pollicis longus
Flexor carpi radialis
Extensor pollicis brevis
Abductor pollicis brevis
Opponens pollicis
Abductor minimi digiti
Flexor digitorum sublimis
Abductor pollicis brevis
Flexor digiti quinti brevis
Flexor pollicis brevis
Adductor pollicis
Flexor digitorum profundus
Lumbricales
First dorsal interosseous

Nerve-supply.—By a branch of the first volar digital ramus of the median nerve. This branch passes over or through the superficial division of the flexor brevis near the origin of the muscle. One or two twigs enter the deep surface of the proximal third of the opponens near its ulnar border.

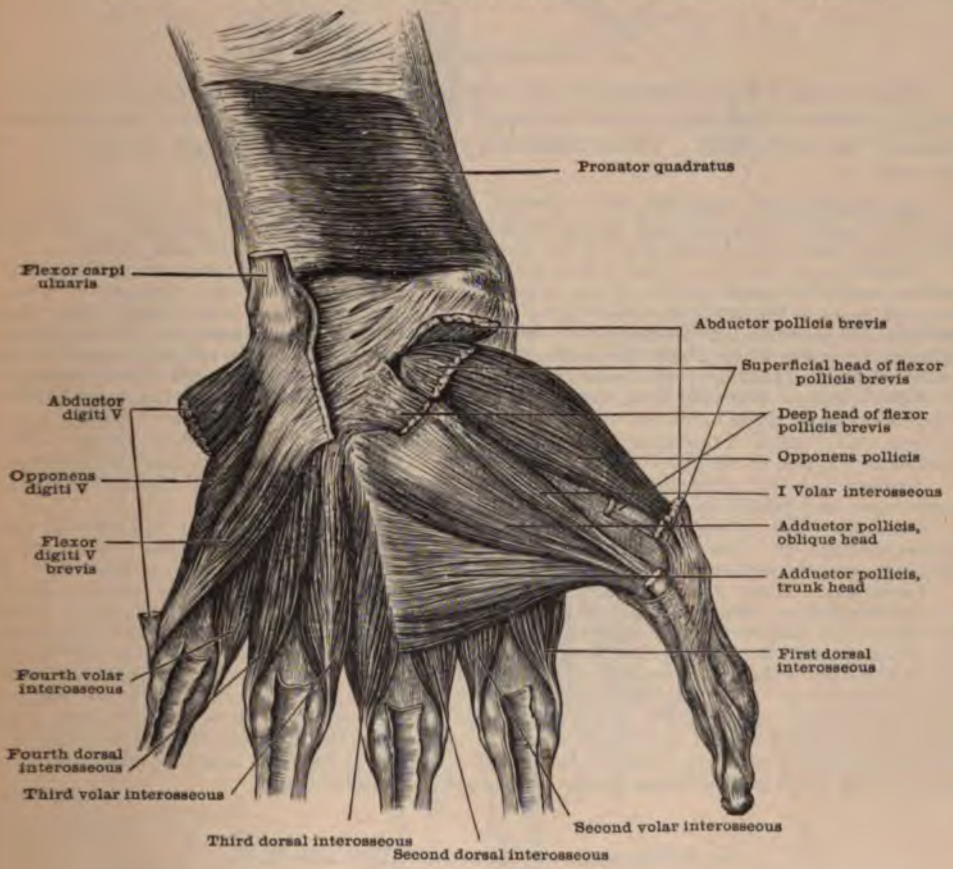
Action.—To flex, adduct, and rotate inwards the first metacarpal bone. The volar surface of the thumb is thus brought to face the volar surface of the other digits.

Relations.—It lies beneath the thenar fascia and the abductor brevis. The flexor brevis overlies its ulnar border.

Variations.—It may be absent or it may be divided into two heads. It is usually more or less fused with the short flexor.

The flexor pollicis brevis (figs. 337, 338).—The muscle is divided by the tendon of the long flexor into a superficial and a deep portion. The **superficial head** arises from the greater multangular bone (trapezium), the adjacent part of the transverse carpal (anterior annular) ligament, and the tendon sheath of the flexor carpi radialis. The fibre-bundles descend closely applied to the opponens, and terminate by a tendon which is attached to the lateral side of the front of the base of the first phalanx. Over the joint a sesamoid bone lies in the tendon. The **deep head** has a tendinous origin from the os multangulum minus (trapezoid) and the os capitatum (magnum). The fibre-bundles take an oblique course, to be inserted into the tendon of the superficial part. A muscle fasciculus which arises from the ulnar side of the base of the first metacarpal and the neighbouring carpal ligaments and is inserted on the ulnar side of the base of the first phalanx, is sometimes considered to be the deep head of the flexor brevis. It is closely bound up with the carpal head of the adductor pollicis and they have a common tendon. Some fibres of the medial division of the tendon may be traced into the aponeurosis of the extensor tendon. It is probable that this portion of the muscle represents a first volar interosseous, and it is so described in this section (p. 398). There is much dispute as to what fasciculi should be included in the flexor brevis.

FIG. 338.—THE PRONATOR QUADRATUS AND DEEP MUSCLES OF THE PALM.


Pronator quadratus
Flexor carpi ulnaris
Abductor pollicis brevis
Superficial head of flexor pollicis brevis
Abductor digiti V
Deep head of flexor pollicis brevis
Opponens pollicis
Opponens digiti V
I Volar interosseous
Adductor pollicis, oblique head
Flexor digiti V brevis
Adductor pollicis, trunk head
First dorsal interosseous
Fourth volar interosseous
Fourth dorsal interosseous
Third volar interosseous
Second volar interosseous
Third dorsal interosseous
Second dorsal interosseous

Nerve-supply.—The muscle is usually supplied by twigs derived from a branch from the first volar digital ramus of the median nerve as this branch passes through its substance, and by twigs from the deep branch of the ulnar. Brookes found this supply in 19 out of 29 instances, in 5 by the median alone, and in 5 by the ulnar alone.

Action.—To flex, adduct, and rotate inwards the metacarpal of the thumb; flex the first phalanx; and extend the second phalanx.

Relations.—Proximally the short flexor is grooved for the tendon of the long flexor, beneath which more distally the deep head of the muscle passes laterally. The superficial portion of the muscle lies beneath the skin. The ulnar border of the deep head is fused proximally with the adductor.

Variations.—The deep head may be absent. Either or both heads may be double. The superficial head may be fused with the abductor brevis, and is usually more or less fused with the opponens.

The adductor pollicis (fig. 338).—*Origin.*—By two heads. The **carpal or oblique head** arises from the deep carpal ligaments, the capitatum and the bases of the second and third metacarpals; the **metacarpal or transverse head,** from the crest of the third metacarpal, from the suprametacarpal fascia of the third interspace, and sometimes also from that of the fourth interspace and from the capsules of the second, third, and fourth metacarpo-phalangeal articulations.

Structure and Insertion.—The fibre-bundles converge towards a tendon which is inserted into the ulnar side of the front of the base of the first phalanx of the thumb. A sesamoid bone lies in the tendon over the joint.

Nerve-supply.—One or more twigs from the deep palmar branch of the ulnar enter the middle third of the muscle on its deep surface.

Action.—To adduct and flex the first metacarpal and flex the first phalanx of the thumb. When the thumb is in an extreme position of apposition, it acts as an abductor.

Relations.—Superficial to the muscle lie some of the tendons of the deep flexor of the fingers and the first two lumbrical muscles. It extends over the two more lateral intermetacarpal spaces, and is in part subcutaneous on the dorsal surface. The deep palmar arch extends between the two heads and beneath the oblique head. The oblique head of the muscle is closely united to the first volar interosseous, so that the latter by some is considered a part of the adductor.

Variations.—The extent of the attachments of origin of the muscle vary considerably. The two heads of the muscle may be more or less completely separated from one another. Each may be divided into separate fasciculi.

(*d*) LUMBRICAL MUSCLES

From the deep flexor tendons in the palm of the hand arise the lumbrical muscles, four in number, which are attached by small tendons to the radial side of the extensor tendons (figs. 334, 336). These lumbrical muscles have homologues in the sole of the foot.

The lumbricales (figs. 336, 337).—*Origin.*—The two lateral arise from the radial side of the volar aspect of the first and second tendons of the flexor digitorum profundus; the two medial arise from the adjacent sides of the second and third and third and fourth tendons.

Structure and Insertion.—The fibre-bundles of each muscle arise directly from the flexor tendons near the distal border of the transverse carpal (anterior annular) ligament. They converge as far as the metacarpo-phalangeal joint, upon a small tendon which begins about the middle of the muscle. The tendon passes out between the palmar aponeurosis and the transverse capitular ligament, winds about the metacarpo-phalangeal joint, expands, and is attached along the side of the first phalanx to the radial border of the tendon of the extensor digitorum communis.

Nerve-supply.—Branches from the median nerve enter the middle third of the radial border of the first two or three lumbrical muscles. The last one or two are supplied by branches from the deep volar branch of the ulnar nerve, which enter the middle third of the deep surface. The third lumbrical and sometimes one or more of the others may receive a branch from both nerves.

Action.—Together with the interosseous muscles they flex the first phalanges on the metacarpal bones and extend the second and third phalanges.

Relations.—The muscles run between the tendons of the flexor profundus and beneath the palmar aponeurosis. They lie upon the fascia covering the interosseous muscles, the capitular ligaments, and the septum over the adductor and deep head of the flexor pollicis brevis.

Variations.—These are very frequent, especially in case of the third and fourth. Each may be doubled or missing. They may arise from the tendons of the flexor sublimis or from the belly of the deep flexor. The first lumbrical may come from the tendon of the long flexor, from the opponens, or the metacarpal of the thumb. The tendon of insertion may go to the ulnar side of the base of the digit opposite that to which the tendon is usually attached, or the tendon may divide and go to the adjacent sides of two fingers. Kopsch has found that in 110 bodies all four lumbricals were inserted on the radial side of their respective digits in 39 per cent. In 35 per cent. the first, second, and fourth were so inserted, while the third sent slips to the adjacent sides of the middle and ring fingers. An accessory fasciculus has been found to arise from the tendon of the flexor pollicis longus and go to the base of the index finger.

(*e*) INTEROSSEOUS MUSCLES (figs. 338–340)

These muscles lie between the metacarpal bones and are covered dorsally and ventrally by fasciæ attached to the metacarpals. In each interspace are two muscles, a dorsal and a palmar. The palmar interossei are inserted into all the fingers except the middle finger, and are adductors towards an axis passing through the middle finger; the dorsal interossei are inserted into both sides of the middle finger and into the radial side of the second and the ulnar side of the fourth finger, and are abductors. All also serve as flexors of the first row of phalanges and extensors of the second and third. In the foot the axis to and from which the interosseous muscles adduct and abduct the toes passes through the second toe.

The **interossei volares** arise from the sides towards the middle finger and the front of the shafts of the first, second, fourth, and fifth metacarpals. The first arises from near the base, the others from three-fourths of the shaft. The fibre-bundles of each muscle converge in a penniform manner upon a tendon which is inserted into the aponeurosis of the digital extensor tendon and the base of the first phalanx on the middle finger side of the corresponding digit (see fig. 334).

The first palmar interosseous is often described as a division of the flexor pollicis brevis or of the adductor pollicis.

The **interossei dorsales** arise from the adjacent sides of the metacarpal bones in each interspace. On the sides nearest the middle finger they cover three-fourths of the bone, on the opposite sides much less. The fibre-bundles converge in a bipenniform manner upon a tendon which begins high in the muscle and is inserted into the aponeurosis of the extensor muscles and the base of the first phalanx on each side of the middle finger, on the thumb side of the index finger, and the ulnar side of the ring finger. The interosseous muscle in the first interspace is thick and strong and forms with the adductor pollicis the fleshy web between the base of the thumb and the palm.

FIG. 339.

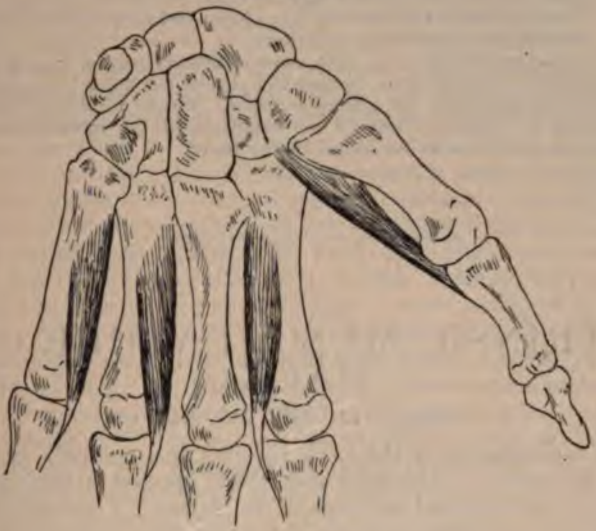
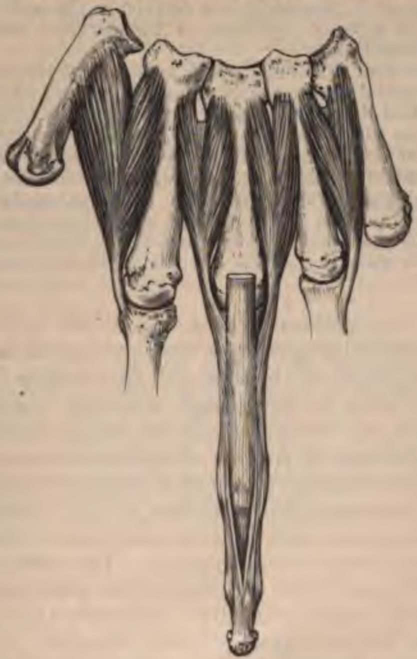


FIG. 340.—THE DORSAL INTEROSSEI.



Nerve-supply.—By branches of the deep palmar division of the ulnar nerve. As a rule, a branch to each volar interosseous enters the proximal third of the muscle. To each dorsal interosseous a branch is given which enters between the two heads. These branches may be variously combined before entering the interosseous muscles.

Action.—To move the fingers towards the radial and ulnar sides, to flex the first phalanx and extend the second and third. The volar interossei move the fingers towards the median axis, the dorsal from it.

Relations.—The volar interossei lie volarwards from the dorsal interossei. The two sets of muscles are bound in place by the dorsal and volar metacarpal fasciæ. The tendons pass out on the dorsal side of the transverse capitular ligament and are closely applied to the metacarpo-phalangeal joints. The muscles of the first two interspaces lie immediately dorsal to the adductor of the thumb; the others dorsal to the flexor tendons.

Variations.—The tendon slip from an interosseous muscle to the base of the first phalanx of a digit may be missing. This is more frequent in case of the volar than in that of the dorsal interossei, and in the medial than the lateral muscles. Either a volar or a dorsal interosseous muscle may be double or missing. Rarely the insertions of the interosseous muscles characteristic of the foot (see p. 472) may be found in the hand.

III. INTRINSIC MUSCULATURE OF THE BACK

(Figs. 341, 342, 343, 344)

The intrinsic musculature of the back consists of a complex system of muscles extending from the sacrum to the skull and closely applied on each side of the body to the back of the vertebræ and the back of the thorax. This intrinsic musculature, which is derived from the dorsal divisions of the embryonic myotomes and is supplied by the posterior divisions of the spinal nerves, comes during subsequent development to be covered in part by muscles and fasciæ derived from the musculature which extends between the axis of the body and the arm, and partly also by muscles which extend from the lateral thoracic region over the back.

The axio-cingular musculature has been taken up in the sections on the muscles of the head, neck, and arm. The trapezius, the levator scapulæ, and the rhomboids (p. 351), which overlie the intrinsic dorsal musculature in the adult, are derived in the embryo from the lateral cervical region, and are supplied by anterior divisions of the cervical nerves. The trapezius is also supplied by the eleventh cranial nerve.

Similarly the latissimus dorsi (p. 360), which arises from the limb bud and is supplied by a nerve arising from the brachial plexus, extends over the lower half of the back and covers the intrinsic dorsal muscles of this region, partly directly, partly by means of an aponeurosis which in the lumbar region becomes fused with the fascia investing the intrinsic dorsal muscles.

From the dorsal part of the thorax a flat layer of musculature, derived from the ventro-lateral portions of the thoracic myotomes and supplied by branches from the intercostal nerves, extends between the axio-cingular and the intrinsic dorsal musculature to the vertebral spines. This musculature (fig. 341), described in the section on the thoracic muscles (p. 417), is composed of two portions, the serratus posterior superior, and the serratus posterior inferior, invested by a fascial membrane which extends across the intervening region over the investing fascia of the intrinsic dorsal muscles.

The intrinsic dorsal musculature is attached to the sacrum, to the ilium, to the spines, transverse, and articular processes and laminæ of the lumbar, thoracic, and cervical vertebræ, to the backs of the ribs and to the base of the skull. Two great longitudinal subdivisions may be recognised, a lateral, supplied by lateral branches of the posterior divisions of the spinal nerves, and a medial, supplied by medial branches. The lateral portion is further divisible into a superficial division, consisting chiefly of systems of muscles extending laterally from the spines of the vertebræ upwards towards the transverse processes of the vertebræ, the ribs, and the mastoid process of the skull; and a deep division, consisting of muscles which extend between successive transverse processes. The medial portion consists chiefly of muscle fasciculi which pass from the transverse processes upwards towards the spines of vertebræ situated more cranially. Between the base of the skull and the first two vertebræ there are several specialised muscles.

The **superficial lateral division** consists of the splenius and the sacro-spinalis. The **splenius** (fig. 341) is a flat, somewhat triangular muscle, which extends from the cervical and upper thoracic spines to the upper cervical transverse processes and to the mastoid process of the temporal bone and the neighbouring part of the occipital. The **sacro-spinalis** (erector spinæ) (fig. 342) is the name given to a mass of musculature which takes its origin from the ilium, the sacrum, and the lumbar and lower thoracic spines. In the lumbar region this muscle divides into its two chief portions, the ilio-costalis and the longissimus. The **ilio-costalis** (fig. 343) is attached to the lumbar transverse processes and to the ribs near the angles, and is continued upwards by accessory fasciculi along the back of the thorax to the transverse processes of the cervical vertebræ. The **longissimus** (fig. 343) extends upwards between the ilio-costalis and the spines of the lumbar and thoracic vertebræ. It is attached to the transverse processes of the lumbar and thoracic vertebræ and to the ribs lateral to the transverse processes. It is continued to the skull by accessory muscle slips. The **spinalis dorsi** (fig. 342) is intimately fused with the longissimus. It extends from the lower to the upper thoracic spines, and is derived from the medial dorsal musculature. The inconstant **spinalis cervicis,** which extends from the upper thoracic to the lower cervical spines, is likewise derived from the medial dorsal musculature, but is less intimately related to the longissimus.

The **medial dorsal musculature** (fig. 344) lies in the groove between the transverse processes and the spines of the sacral, lumbar, thoracic, and cervical vertebræ. It extends from the sacrum to the skull, and is best developed in the lumbar and cervical regions. It is subdivided into a vertebro-occipital muscle (semispinalis capitis), a transverso-spinal group, and the interspinal muscles. The **semispinalis capitis** (complexus) (fig. 342) extends from the mid-thoracic region to the base of the skull. The **transverso-spinal** group (fig. 344) extends from the sacrum to the second cervical vertebra. It is more or less artificially divisible into several layers. In the superficial layer, the **semispinalis dorsi et cervicis,** which extends from the twelfth thoracic to the second cervical vertebra, the constituent fasciculi extend from the transverse process of one vertebra to the spine of a vertebra four to six segments above. In the middle layer, the **multifidus,** the fasciculi extend over from two to four vertebræ. In the deepest layer, the **rotatores,** the fasciculi extend to the next vertebra (short rotators) or to the second vertebra above (long rotators). The **interspinal** muscles extend between successive spines.

The **intertransverse** muscles are best developed in the cervical and lumbar regions. In the cervical region intertransverse muscles belonging to the dorsal musculature extend between the successive posterior tubercles, while intertransverse muscles belonging to the ventral musculature extend between the anterior tubercles. The latter, as well as the rectus capitis anterior, which belongs in the series, have been described above (p. 350). With the series of posterior intertransverse cervical muscles the **rectus capitis lateralis** (fig. 315), which extends from the atlas to the skull, may be appropriately included.

The muscles which pass from the first two vertebræ to the base of the skull behind, or **suboccipital muscles** (fig. 343), consist of the **rectus capitis posterior minor,** from the spine of the atlas to the skull, and **rectus capitis posterior major,** from the spine of the epistropheus (axis) to the skull; of the **obliquus capitis inferior,** from the spine of the epistropheus (axis) to the transverse process of the atlas; and the **obliquus capitis superior,** from the transverse process of the atlas to the base of the occipital bone.

The primitive condition of the dorsal musculature is one of metameric segmentation. This is characteristic of fishes, many amphibia, and of the embryos of all higher vertebrates. In the tailless amphibia, however, a partial differentiation of the dorsal musculature takes place during embryonic development, and in all higher forms a differentiation takes place which corresponds in many ways to that described above for man. According to Favaro, the splenius is differentiated from the medial dorsal system, but its innervation should place it with the lateral system. In the human embryo the dorsal segmental musculature extends into the tail region, but afterwards here undergoes retrograde metamorphosis.

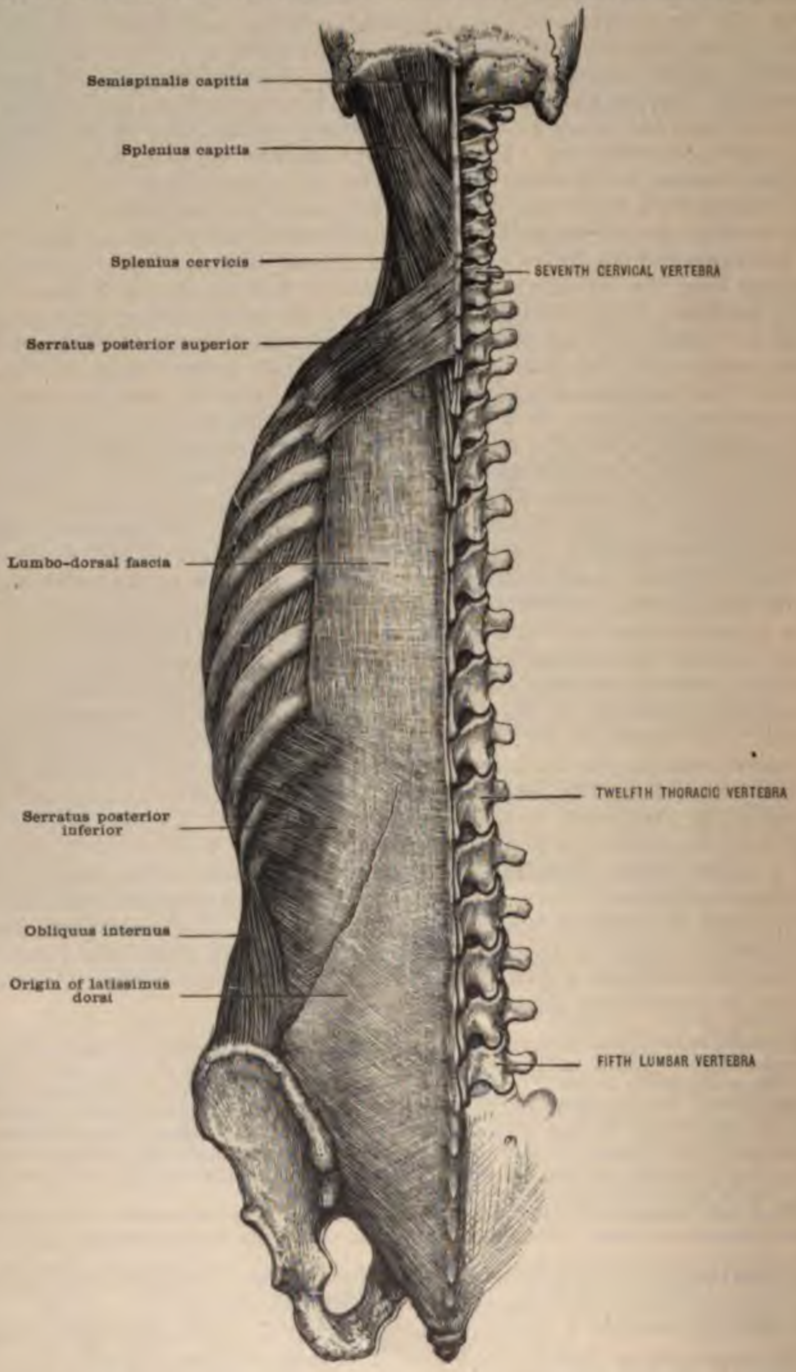
The intrinsic musculature of the back serves to extend, bend from side to side, and to rotate the spinal column and head. The muscles attached to the ribs serve to depress the thorax.

The **fasciæ** and the general relations of the muscles of the back may be followed in the cross-sections shown in figs. 311, 314, 320, 345, and 355.

The **tela subcutanea** of the upper dorsal region has been described in connection with the axio-cingular muscles (p. 337). It is thick, fibrous, and adherent. In the lower dorsal region it is somewhat less compact, but is thicker and contains more fat. It is usually divisible into two layers, of which the deeper is adherent to the lumbodorsal fascia.

The splenius (fig. 341) is enveloped in a thin, adherent fascial covering. The sacro-spinalis is covered by a fascia, the **fascia lumbo-dorsalis** (fig. 341), which inferiorly is attached to the iliac crest, the distal and lateral margins of the sacrum, and the sacral spines. In the lumbar and thoracic regions it is attached medially to the vertebral spines. Laterally, in the lumbar region, it is reflected around the muscle to its ventral surface, where an 'anterior layer' forms an intermuscular septum (fig. 345) between the quadratus lumborum and the sacro-spinalis. This intermuscular septum (fig. 344) extends from the twelfth rib to the iliac crest and the

Fig. 341.—The Third and Fourth Layers of the Muscles of the Back.


Semispinalis capitis
Splenius capitis
Splenius cervicis
SEVENTH CERVICAL VERTEBRA
Serratus posterior superior
Lumbo-dorsal fascia
TWELFTH THORACIC VERTEBRA
Serratus posterior inferior
Obliquus internus
Origin of latissimus dorsi
FIFTH LUMBAR VERTEBRA

ilio-lumbar ligament, and is attached medially to the transverse processes of the lumbar vertebræ, from which fibre-bands extend laterally into it. It is strengthened above by fibre-bundles which pass from the first and second lumbar vertebræ to the twelfth rib (lumbo-costal ligament). (For the relation of the abdominal muscles to this fascia see p. 415.)

In the thoracic region (fig. 345) the lumbo-dorsal fascia is attached to the ribs lateral to the ilio-costal muscle. In the cervical region (fig. 314) the fascia is continued into the intermuscular septa which surround the muscles of this group in the neck.

The *transverso-spinal muscles* are covered throughout their extent by a fascial membrane which serves to separate them from the longissimus in the sacral, lumbar, and thoracic regions, and from the semispinalis capitis in the upper thoracic and cervical regions.

In the dorsal region of the neck (figs. 311, 314, 320) the muscles are covered on each surface by adherent fascial sheets, **fascia nuchæ,** and are arranged in several concentric layers, each of which is separated from its neighbours by dense fatty areolar tissue. The deepest of the layers is formed by the muscles of the transverso-spinal group. This is covered by a dense membrane, and is separated from the semispinalis capitis (complexus) by a thick layer of areolar tissue containing the chief blood-vessels and nerves of the neck. The semispinalis capitis (complexus) is covered on each surface by a more delicate adherent membrane, and is separated from the splenius by loose tissue. The splenius has a somewhat denser adherent fascial covering, into which the fascia of the levator scapulæ is continued. Separated from this by areolar tissue lies the trapezius. The cervical and thoracic portions of the semispinalis are separated by delicate membranous septa from the semispinalis capitis (complexus), the levator scapulæ, and the splenius. The muscles of each side are separated in the dorsal median plane by the dense **ligamentum nuchæ,** into which the various cervical septa and fasciæ extend. The suboccipital muscles are covered by fascial sheaths which are so fused as to constitute a special fascia for these muscles. Distally this is continued into the fascia of the transverso-spinal muscles.

MUSCLES

A. SUPERFICIAL LATERAL DORSAL SYSTEM

The splenius (fig. 341).—The two parts of which this muscle is composed may be separately considered.

The splenius cervicis.—*Origin.*—By a narrow aponeurotic band from the spinous processes of the third to the sixth thoracic vertebræ.

Structure and Insertion.—The fibre-bundles extend upwards and laterally and give rise to a flat muscle sheet from which fasciculi arise that are inserted by short tendinous processes on the posterior tubercles of the first two or three cervical vertebræ. The processes are often united with those of the levator scapulæ.

The splenius capitis.—*Origin.*—From the ligamentum nuchæ in the region of the third to the seventh cervical vertebræ and from the spinous processes of the first two to five thoracic vertebræ.

Structure and Insertion.—The fibre-bundles form a sheet which continues cranialwards that of the splenius cervicis. The fibre-bundles converge somewhat and are inserted by a short, broad, thick tendon into—(1) the back, the side, and the tip of the mastoid process below the sterno-cleido-mastoid muscle, and (2) into the neighbouring part of the occipital bone.

Relations.—The splenius lies dorsal to the semispinalis capitis (complexus) and to the cervical (transversalis cervicis) and the cranial (trachelo-mastoid) portions of the longissimus and the cervical portion (cervicalis ascendens) of the ilio-costalis and to the levator scapulæ, and is partly covered by the trapezius, sterno-cleido-mastoid, serratus posterior superior, and the rhomboids. In the triangle bounded by the trapezius, sterno-cleido-mastoid, and the levator scapulæ it is subcutaneous.

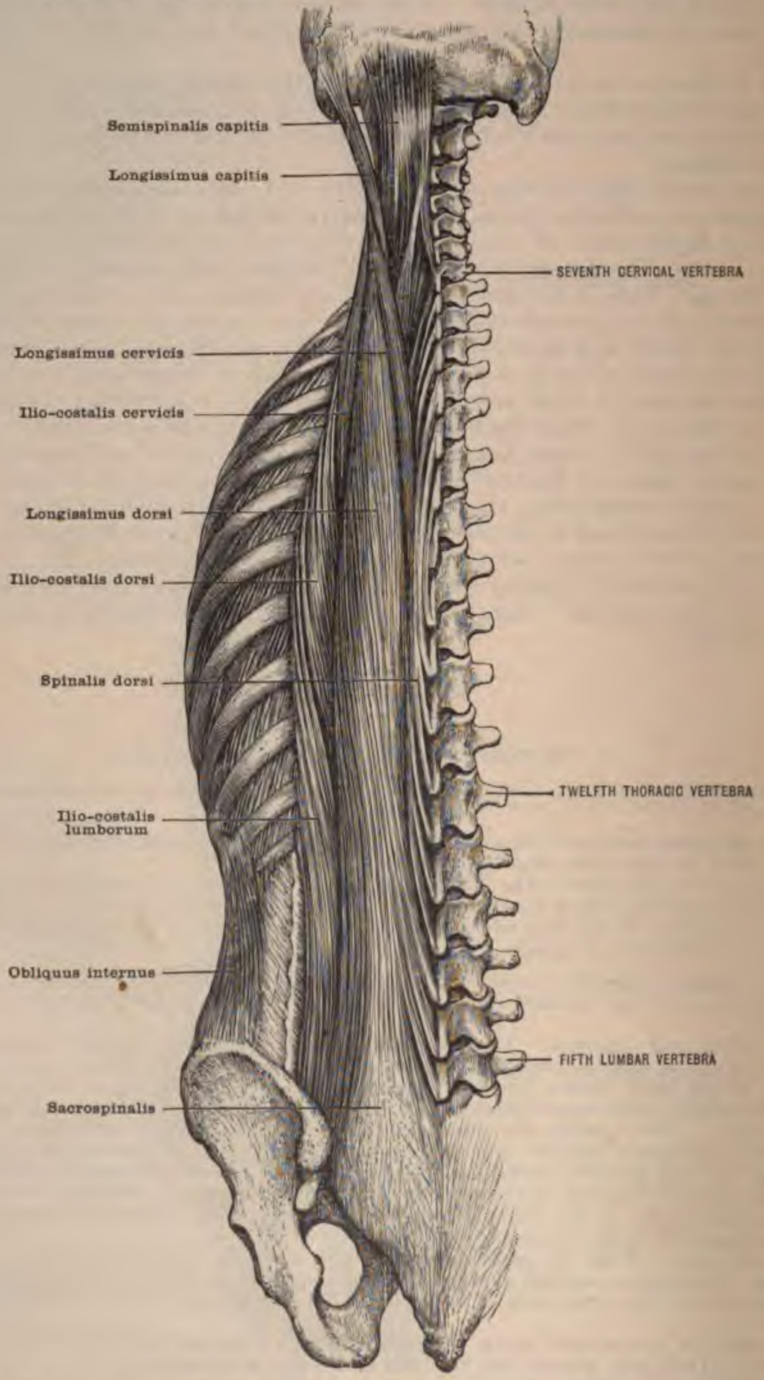
Nerve-supply.—From the second cervical nerve a branch enters the superior portion of the splenius. The lateral branches of the posterior divisions of the third and fourth cervical nerves give branches to the lower part of the muscle. These rami enter the outer part of its deep surface.

Action.—To incline and rotate the head and neck towards the side on which the muscle is placed. When both muscles act, the head and neck are extended.

Variations.—The extent of separation and of fusion of the two muscles varies. Absence of either muscle is rare. The splenius capitis may be divided into mastoid and occipital portions. The attachment of the muscle also varies somewhat. Occasionally the spinal origin of the splenius may extend to the cranial end of the ligamentum nuchæ. An accessory slip, the **splenius cervicis accessorius,** separated from the main muscle by the tendon of the serratus posterior superior, is frequently (8 per cent. of instances, LeDouble) found to run from the lower cervical or upper thoracic vertebræ to the transverse process of the atlas.

The sacro-spinalis (erector spinæ).—*Origin.*—(1) From a strong aponeurosis attached t the spines of the last two or three thoracic, the lumbar, and the sacral vertebræ, to the ligament

FIG. 342.—THE FIFTH LAYER OF THE MUSCLES OF THE BACK.


Semispinalis capitis
Longissimus capitis
SEVENTH CERVICAL VERTEBRA
Longissimus cervicis
Ilio-costalis cervicis
Longissimus dorsi
Ilio-costalis dorsi
Spinalis dorsi
TWELFTH THORACIC VERTEBRA
Ilio-costalis lumborum
Obliquus internus
FIFTH LUMBAR VERTEBRA
Sacrospinalis

passing from the sacrum to the coccyx, to the lateral margins of the last three sacral vertebr and to the dorsal fifth of the iliac crest; (2) directly from the iliac crest in front of and later to the attachment of the aponeurosis; and (3) from the lateral margin of the upper part of th back of the sacrum. The aponeurosis covers the muscles of the sacral region and is there unite to the overlying fascia by more or less dense areolar tissue. Opposite the iliac crest fibre-bundles begin to take origin from the lateral margin of the dorsal surface as well as from the deep or ventral surface of the aponeurosis of origin, and gradually the line of dorsal attachment extends medially until, in the lower thoracic region, the tendon becomes completely embedded in the muscle-fasciculi which take their origin from it. The aponeurosis, which is the strongest in the lower lumbar region, is composed chiefly of fibres which take a direction upwards and somewhat lateralwards.

In the lower lumbar region the sacro-spinalis (erector spinæ) muscle begins to show a distinct division into its two chief component parts, the ilio-costalis and the longissimus. In the upper lumbar region the spinalis becomes more or less distinct from the longissimus. Each of these three muscles may, therefore, here be taken up individually. The parts of which the ilio-costalis and longissimus are composed will be taken up separately.

The ilio-costalis lumborum (figs. 342, 343).—*Origin.*—(1) Chiefly from the back of the sacro-spinal aponeurosis, medial to and cranialwards from the iliac crest, and (2) from the iliac crest directly. The deep medial surface of the muscle is closely united in the lumbar region to the longissimus.

Structure and Insertion.—From the mass of fibre-bundles which compose the muscle, fasciculi are given off which are attached chiefly by tendinous slips to—(1) the tips of the transverse processes of the lumbar vertebræ; (2) the fibrous processes which extend outwards from the tips of the transverse processes of the upper lumbar vertebræ into the anterior layer of the lumbo-dorsal fascia; (3) the inferior margin of the last six or seven ribs near the angles. The insertions into the lumbo-dorsal fascia and the twelfth rib are usually fleshy.

Relations.—The muscle lies on the lateral margin of the longissimus and upon the ribs and the external intercostal muscles, and under the axio-appendicular muscles described above.

The ilio-costalis dorsi (accessorius).—*Origin.*—By fleshy fasciculi from the superior borders of the lower seven ribs medial to the angles.

Structure and Insertion.—The slips of origin lie beneath the preceding portion of the muscle, pass medial to it, and give rise to a belly from which tendinous slips extend to be inserted into the upper seven ribs near their angles and to the transverse process of the seventh cervical vertebra.

Relations.—The muscle lies upon the ribs and the external intercostal muscles lateral to the longissimus.

The ilio-costalis cervicis (cervicalis ascendens).—*Origin.*—By fleshy slips from the upper borders near the angles of the seventh to the third ribs.

Structure and Insertion.—The slips of origin are covered by the slips of insertion of the dorsal portion (accessorius). They emerge medial to them and give rise to a fleshy belly from which tendons pass to the backs of the transverse processes of the sixth to the fourth cervical vertebræ.

Relations.—The scalenus posterior lies in front, the levator scapulæ at the side, and the splenius and longissimus (transversalis) cervicis medial to this muscle.

The longissimus dorsi (figs. 342, 343).—*Origin.*—(1) From the deep surface of the sacro-spinal aponeurosis; (2) from the rough area on the medial surface of the ilium, and from the lateral portion of the dorsal surface of the upper part of the sacrum; and (3) through accessory slips which arise from the transverse processes of the first two lumbar and the last five or six thoracic vertebræ. In the lumbar region it is fused dorso-laterally with the ilio-costalis.

Structure and Insertion.—From the muscle mass arise fasciculi which are inserted partly directly, partly by means of tendons, into—(1) the lower border of the back of the transverse processes of the lumbar vertebræ and the inferior margins of the ribs lateral to the tubercles; and (2) the accessory tubercles of the lumbar and the tips and inferior margins of the transverse processes of the thoracic vertebræ. The attachment to the first rib is usually wanting. The attachment to the first five ribs may fail. The medial attachments seldom extend to the first vertebra.

Relations.—The lateral margin of the muscle is covered by the ilio-costalis. Medially it overlies the transverso-spinal muscles. The lateral branches of the dorsal veins, arteries, and nerves pass mainly in the fibrous tissue which separates the longissimus from the ilio-costalis, the medial branches chiefly between the longissimus and the transverso-spinal muscles. The relations to the axio-appendicular muscles and to the dorsal fascia have been pointed out above. Ventrally it lies upon the intertransverse muscles, the external intercostals, and the levatores costarum.

The longissimus cervicis (transversalis cervicis).—*Origin.*—By tendinous slips from the transverse processes of the first four to six thoracic vertebræ.

Structure and Insertion.—The fasciculi which arise from these slips give rise to a muscle belly from which tendons of insertion extend to the posterior tubercles of the transverse processes of the mid-cervical vertebræ.

Relations.—This muscle lies between the longissimus dorsi and capitis and the ilio-costalis dorsi (accessorius) and cervicis (cervicalis ascendens) muscles. It is frequently fused with the longissimus capitis.

The longissimus capitis (trachelo-mastoid).—*Origin.*—By tendinous slips from the transverse processes of the first three or four thoracic vertebræ and the articular processes of the last four cervical.

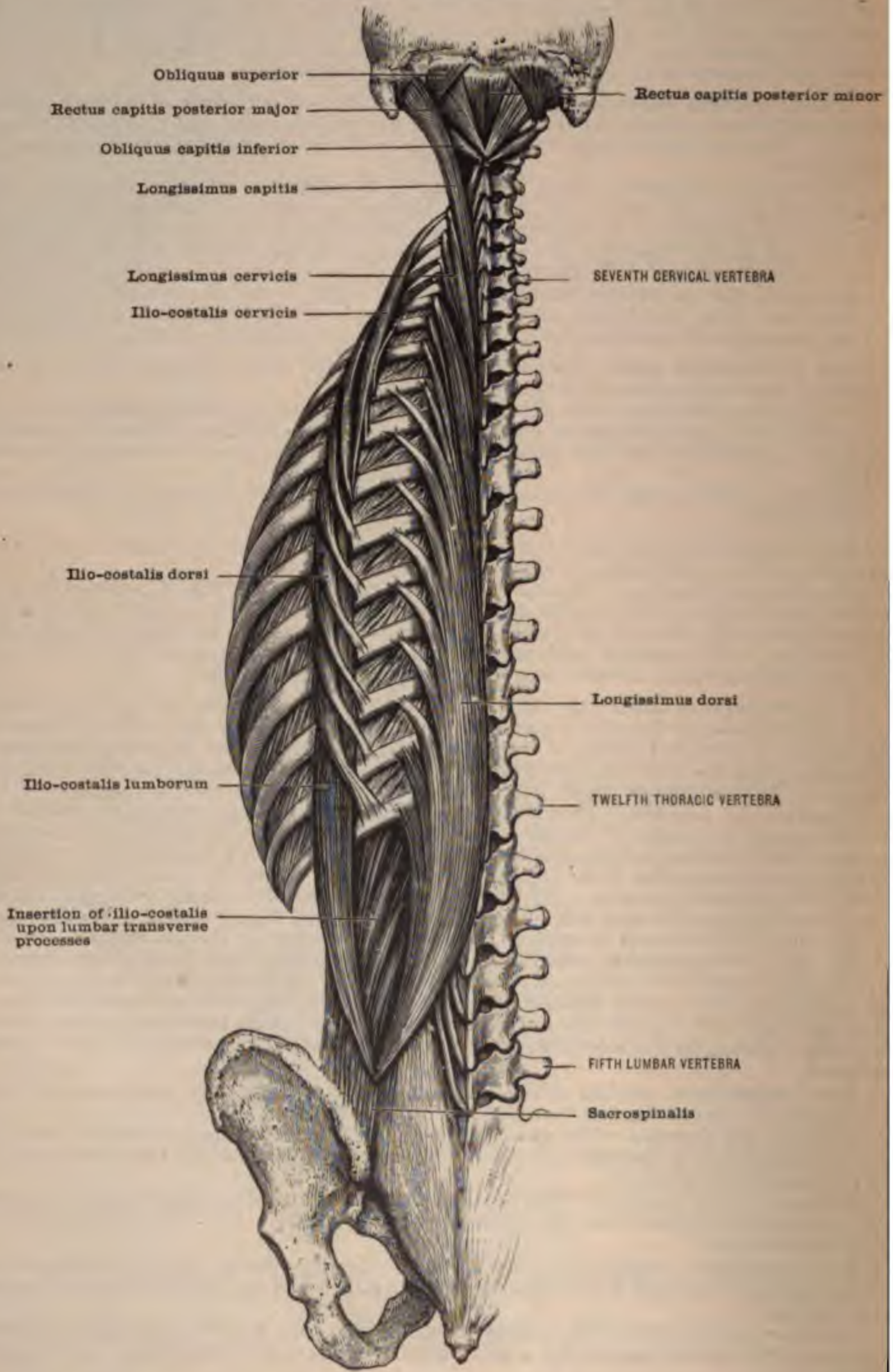
Structure and Insertion.—The muscle fasciculi arising from these tendons form a belly which is united to the mastoid process by a short tendon. A tendinous inscription often crosses the muscle.

Relations.—It lies ventral to the splenius capitis, lateral to the semispinalis capitis (complexus) and medial to the longissimus cervicis (cervicalis ascendens).

The spinalis dorsi.—*Origin.*—By tendinous bands from the tips of the two upper lumbar and the last two thoracic spines.

Structure and Insertion.—From the deep surface of the tendinous bands there arises a long

FIG. 343.—THE FIFTH LAYER OF THE MUSCLES OF THE BACK, AFTER SEPARATING THE OUTER AND MIDDLE DIVISIONS.


Obliquus superior
Rectus capitis posterior major
Obliquus capitis inferior
Longissimus capitis
Longissimus cervicis
Ilio-costalis cervicis
Ilio-costalis dorsi
Ilio-costalis lumborum
Insertion of ilio-costalis upon lumbar transverse processes
Rectus capitis posterior minor
SEVENTH CERVICAL VERTEBRA
Longissimus dorsi
TWELFTH THORACIC VERTEBRA
FIFTH LUMBAR VERTEBRA
Sacrospinalis

slender muscle belly which is fused laterally with the longissimus dorsi. It is attached by tendinous processes to the spines of the upper thoracic vertebræ, usually the second or third to the ninth.

The spinalis cervicis.—An inconstant muscle which arises from the spines of the two upper thoracic and two lower cervical vertebræ and extends to the spines of the second to the fourth cervical vertebræ.

Nerve-supply of the sacro-spinalis.—All parts of the muscle except the spinalis dorsi and cervicis are supplied by twigs from the lateral branches of the posterior divisions of the spinal nerves. The spinalis muscles are said to be supplied by twigs from the medial branches. The exact distribution of these branches is too complex to be treated here.

Action of the sacro-spinalis.—The sacro-spinalis serves, when acting on one side, to bend the spinal column towards that side, and when acting on both sides, to extend the spinal column. The cranial portions of the muscle serve to incline the head towards the same side, and when both muscles act they serve to extend the head. The ilio-costalis muscle has the greatest power for producing lateral inclination. The ilio-costalis lumborum serves to depress the ribs, while the ilio-costalis cervicis (cervicalis ascendens) may aid in elevating them. The spinalis muscle serves merely as an extensor.

Variations of the sacro-spinalis.—The slips of origin and insertion of the various parts of this muscle and the extent of fusion of the various parts vary greatly. Statistical data from which the most frequent conditions might be determined are wanting. Tendinous inscriptions may extend across the longissimus cervicis and other parts of the sacro-spinalis.

B. Medial Dorsal System

1. Vertebro-occipital Muscle

The semispinalis capitis (complexus) (fig. 342).—This muscle is usually separated from the semispinalis muscles of the back and neck by a well-marked septum and has a distinctive structure.

Origin.—(1) By long tendinous fasciculi from the tips of the transverse processes of the upper five or six thoracic vertebræ and of the seventh cervical vertebra; (2) by short fleshy processes from the articular processes and bases of the transverse processes of the three or four lowest cervical vertebræ; and (3) by delicate fleshy fasciculi from the spinous processes of the upper thoracic and lower cervical vertebræ.

Structure and Insertion.—The slightly diverging fibre-bundles form a long, flat belly which is inserted, partly by means of an aponeurosis which covers the muscle laterally, into the lower surface of the squamous portion of the occipital, between the superior and inferior nuchal lines. There is often a transverse tendinous inscription across the muscle opposite the sixth cervical vertebra, and less frequently one between the upper and middle thirds of the muscle. These are best marked in the medial portion of the muscle, which comes from the thoracic vertebræ and is sometimes separately designated as the **spinalis capitis (biventer cervicis).**

Nerve-supply.—It is supplied chiefly by the medial branches of the posterior divisions of the first four or five cervical nerves.

Relations.—It lies dorso-lateral to the suboccipital muscles and to the semispinalis cervicis. From this latter it is separated by a septum containing the descending branch of the occipital artery, the deep cervical artery, and the medial dorsal branches of the cervical nerves. It is covered laterally by the longissimus capitis (trachelo-mastoid), and dorsally by the splenius, and above the upper margin of the splenius by the trapezius.

Action.—To extend the head and to incline it slightly towards the same side.

Variations.—The origin of the muscle may extend to the eighth thoracic vertebra or merely to the first thoracic. It may be fused with the longissimus (transversalis) cervicis. A special fasciculus may run beneath the muscle from the upper thoracic vertebræ to the head.

2. Transverso-spinal Muscles

The semispinalis dorsi et cervicis (fig. 344).—This superficial transverso-spinal muscle sheet extends from the twelfth thoracic to the second cervical vertebra. The fasciculi which compose it arise by short tendons from the backs of the transverse processes, and are inserted by short tendons into the spines.

The semispinalis dorsi.—*Origin.*—From the sixth to the tenth or twelfth thoracic vertebræ.

Insertion.—The upper four to six thoracic and the last two cervical vertebræ. The fasciculi extend over four to six vertebræ.

The semispinalis cervicis.—*Origin.*—From the upper five or six thoracic vertebræ.

Insertion.—Into the fifth to the second cervical vertebræ. The fasciculi extend over four to five vertebræ.

Relations.—This muscle lies beneath the longissimus dorsi and the semispinalis capitis (complexus) and over the following musculature.

The multifidus (fig. 344).—This second layer of transverso-spinal musculature extends from the sacrum to the second cervical vertebra. It is best developed in the lumbar region and least so in the thoracic.

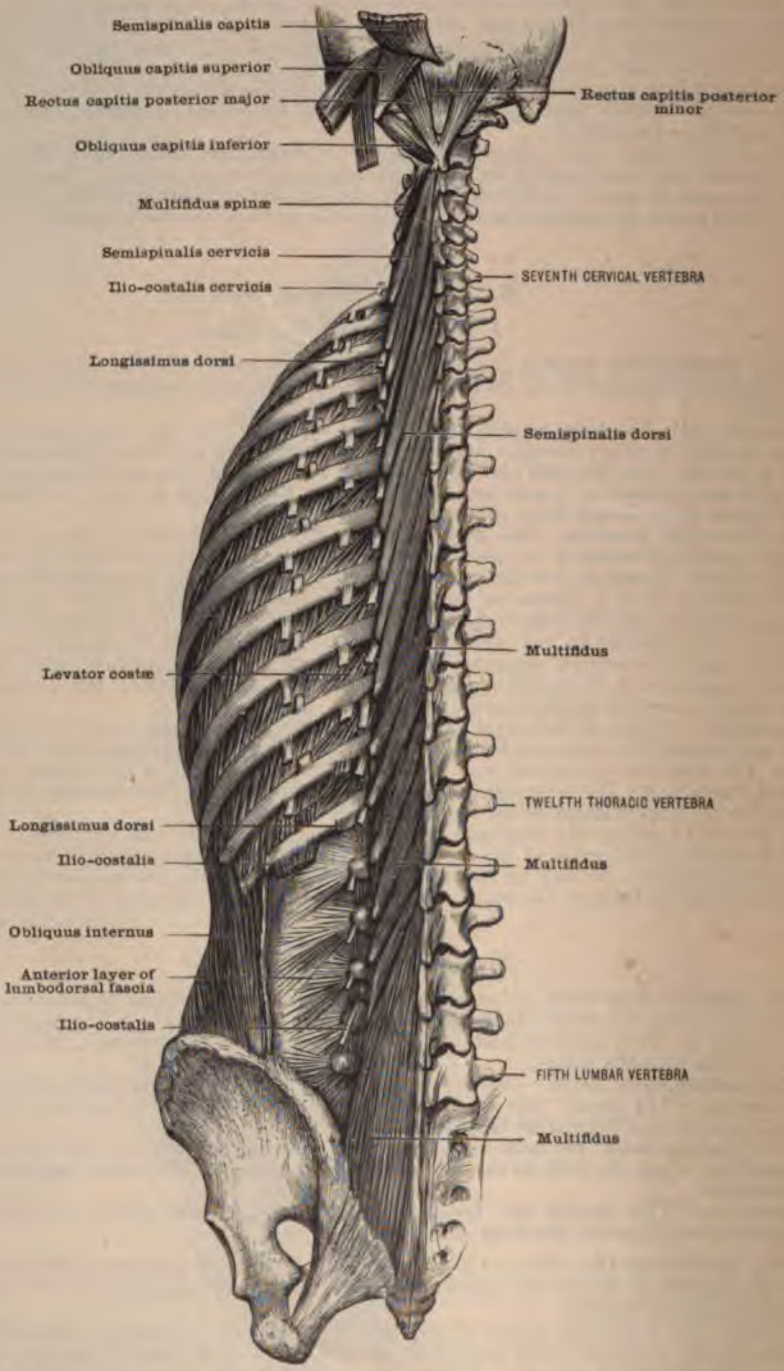
Origin.—(1) From the groove on the back of the sacrum between the spines and the articular elevations, from the dorsal sacro-iliac ligaments, and from the deep surface of the aponeurosis of the sacrospinal muscle; (2) from the mammary and accessory processes of the lumbar vertebræ; (3) from the backs of the transverse processes of the thoracic vertebræ; and (4) from the articular processes of the fourth to the seventh cervical vertebræ and the back of the transverse process of the seventh.

Insertion.—Spinous processes of the lumbar, thoracic, and six lower cervical vertebræ.

Structure.—The more superficial fasciculi arise by short tendinous processes, the deeper ones directly. The more superficial fasciculi extend to the fourth vertebra above, the middle to the third, and the deepest to the second above.

The rotatores.—These, the third layer of transverso-spinal muscles, extend from the sacrum to the second cervical vertebra. They are composed of short fleshy fasciculi which extend to the second vertebra above (*rotatores longi*) and to the first above (*rotatores breves*). The fasciculi arise from the back and upper borders of the transverse processes or their homologues, and are inserted into the laminæ of the preceding vertebræ. They are best developed in the thoracic region. Some authors consider the rotatores breves confined to the thoracic region.

Fig. 344.—The Transverso-spinalis.


Semispinalis capitis
Obliquus capitis superior
Rectus capitis posterior major
Obliquus capitis inferior
Rectus capitis posterior minor
Multifidus spinæ
Semispinalis cervicis
Ilio-costalis cervicis
SEVENTH CERVICAL VERTEBRA
Longissimus dorsi
Semispinalis dorsi
Multifidus
Levator costæ
TWELFTH THORACIC VERTEBRA
Longissimus dorsi
Ilio-costalis
Multifidus
Obliquus internus
Anterior layer of lumbodorsal fascia
Ilio-costalis
FIFTH LUMBAR VERTEBRA
Multifidus

3. The Interspinal Muscles

The **interspinales** consist of short fasciculi which extend from the upper surface of the spine of each vertebra near its tip to the lower surface of the spine of the vertebra above. In the neck the muscles lie in pairs between the bifid extremities of the vertebræ. In the lumbar region they form broad bands attached to the whole length of the spinous processes and are separated by the interspinous ligaments. In the thoracic region they usually are undeveloped.

Nerve-supply of medial dorsal muscles.—These are all supplied by the medial branches of the posterior divisions of the spinal nerves.

Action of medial dorsal muscles.—These muscles serve to extend the spinal column when acting on both sides. When acting on one side, they produce a movement of rotation towards the opposite side.

C. DEEP LATERAL DORSAL MUSCLES

The intertransversarii.—These are vertical bands composed of short bundles which pass between the transverse processes of the cervical, lumbar, and the lower thoracic vertebræ.

(*a*) **Cervical** (fig. 315).—Anterior and posterior muscles are found in the cervical region. The anterior muscles run between the anterior tubercles of the vertebræ, are homologous with the intercostal muscles, are supplied by branches from the ventral divisions of the corresponding spinal nerves, and have been described above (p. 351). The posterior muscles run between the dorsal tubercles and belong to the intrinsic dorsal musculature. They are supplied by the lateral branches of the posterior divisions of the cervical nerves.* The first pair of muscles extends between the atlas and axis, the lowest passes to the transverse process of the first thoracic vertebra. The vertebral artery runs vertically between each pair of muscles above the sixth, and the anterior division of each cervical nerve passes laterally between the artery and the posterior muscle in each space, and then out between the two muscles. The posterior division of each cervical nerve passes dorsal to each posterior muscle.

(*b*) **Thoracic.**—Small muscle fasciculi may extend between the ends of the transverse processes of the thoracic vertebræ and between the last thoracic and first lumbar. They are most frequent in the lower thoracic region. Often they are replaced by tendinous bands.

(*c*) **Lumbar** (fig. 344).—In the lumbar region there is a lateral set of muscles connecting the adjacent surfaces of the ends of the transverse processes and a medial connecting the mammary tubercle of one vertebra to the mammary or the accessory tubercle of the vertebra next above. They extend between each two of the five lumbar vertebræ and sometimes also to the first sacral. They lie between the sacrospinalis and psoas muscles. They are supplied by the lateral branches of the posterior divisions of the spinal nerves.†

Action.—The intertransverse muscles serve to bend the spinal column laterally, and when acting on both sides, to make it rigid.

Variations.—The number of intertransverse spaces occupied by the muscles varies, especially in the thoracic region. They may be doubled or extend over more than one interspace.

The rectus capitis lateralis (fig. 315).—*Origin.*—From the upper surface of the transverse process of the atlas.

Structure and Insertion.—The fibre-bundles give rise to a quadrilateral sheet which passes upwards to be inserted on the under surface of the jugular process of the occipital bone.

Nerve-supply.—The anterior branch of the suboccipital (first cervical) nerve gives twigs to its ventral surface.

Action.—To flex the head laterally.

Relations.—In front lie the anterior primary division of the suboccipital nerve and the internal jugular vein. Behind the muscle lie the superior oblique and the longissimus capitis (trachelo-mastoid) muscles and the atlanto-occipital joint.

Variations.—It may be absent or doubled.

D. SUBOCCIPITAL MUSCLES

(Figs. 343, 344)

The rectus capitis posterior major.—*Origin.*—From the upper surface of the spine of the epistropheus.

Structure and Insertion.—The muscle-fibres diverge to form a broad triangular band which is inserted into the lateral half of the inferior nuchal line of the occipital bone and the area below it. Its insertion is immediately below that of the obliquus superior.

The rectus capitis posterior minor.—*Origin.*—From the upper part of the side of the posterior tubercle of the atlas.

Structure and Insertion.—The fibre-bundles diverge to form a flat, triangular sheet inserted below the medial third of the inferior nuchal line of the occipital bone on the inferior surface of the squama occipitalis.

The obliquus capitis inferior.—*Origin.*—From the upper part of the side of the spine of the epistropheus (axis).

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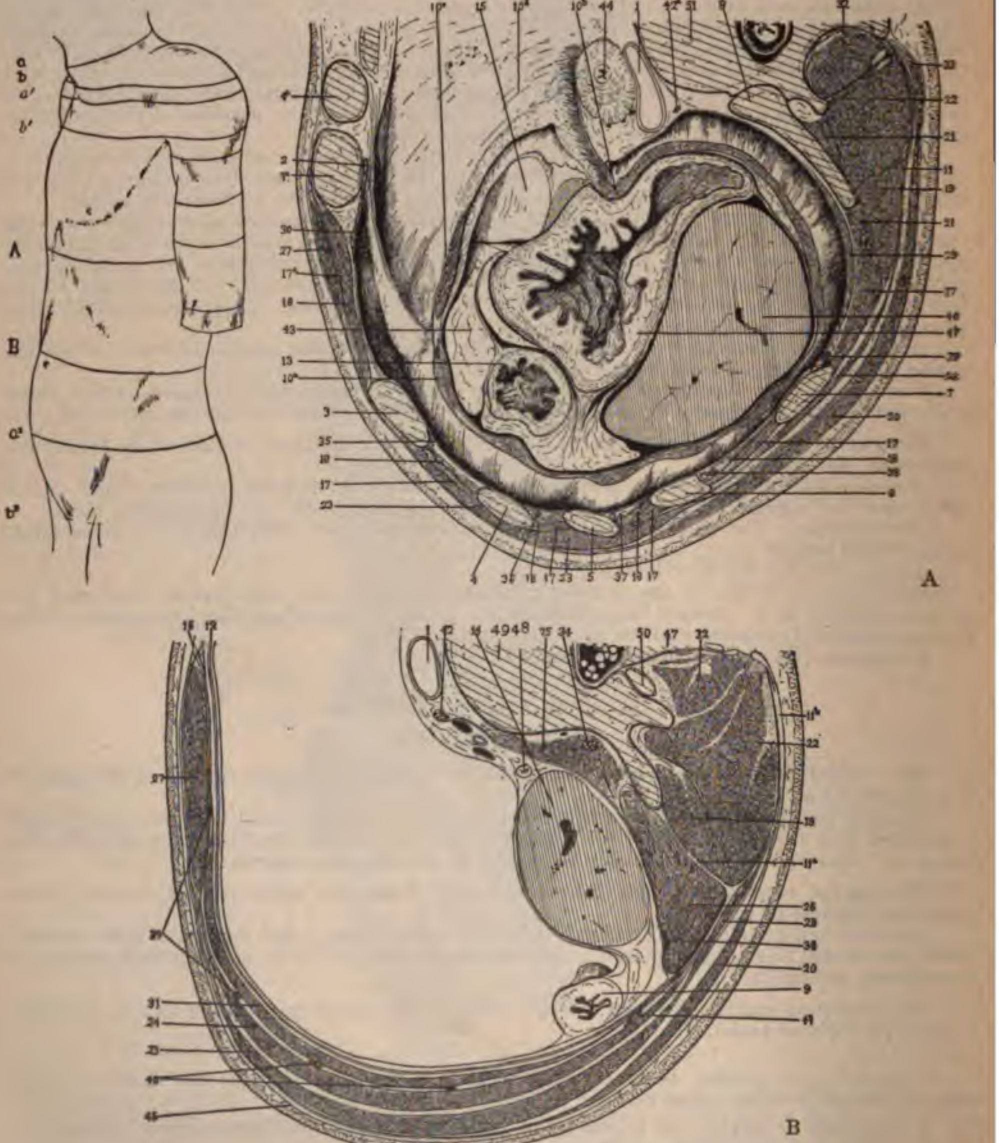
*According to Lickley, both sets of cervical intertransverse muscles are supplied by the anterior divisions of the spinal nerves.

† According to Lickley, the lateral set of muscles is supplied by branches from the anterior divisions of the corresponding spinal nerves.

FIG. 345. A and B.—SECTIONS THROUGH THE LEFT SIDE OF THE TRUNK IN THE REGIONS SHOWN IN THE DIAGRAM.

The muscles of the body wall have been slightly pulled apart in order to reveal the relations of muscles, fasciæ, and aponeuroses. *a* and *b* in the diagram indicate sections A and B, fig. 314 (p. 346); *a′* and *b′*, sections A and B, fig. 320 (p. 357); *a″* and *b″*, sections A and B, fig. 354 (p. 428).

1. Aorta. 2. Internal mammary artery. 3. VI rib—a, cartilage. 4. VII rib—a, cartilage. 5. VIII rib. 6. IX rib. 7. X rib. 8. XI rib. 9. Descending colon. 10. Diaphragm—a, costal portion; b, lumbar portion; c, sternal portion; d, centrum tendineum. 11. Lumbodorsal fascia—a, anterior layer; b, posterior layer. 12. Transversalis fascia. 13. Left colic flexure. 14. Kidney. 15. Liver. 16. Linea alba. 17. Intercostales externi—a, ligament. 18. Intercostales interni. 19. Ilio-costalis. 20. Latissimus dorsi. 21. Levator costæ. 22. Longissimus dorsi. 23. Obliquus abdominis externus. 24. Obliquus abdominis internus. 25. Psoas major. 26. Quadratus lumborum. 27. Rectus abdominis. 28. Serratus posterior inferior. 29. Subcostalis. 30. Transversus thoracis. 31. Transversus abdominis. 32. Transverso-spinales. 33. Trapezius. 34. I lumbar nerve. 35. VI thoracic nerve. 36. VII thoracic nerve. 37. VIII thoracic nerve. 38. IX thoracic nerve. 39. X thoracic nerve. 40. XI thoracic nerve. 41. XII thoracic nerve. 42. Sympathetic trunk—a, great splanchnic nerve. 43. Great omentum. 44. Œsophagus. 45. Scarpa's fascia. 46. Spleen. 47. Stomach. 48. Ureter. 49. II lumbar vertebra. 50. III lumbar vertebra. 51. XI thoracic vertebra.


a
b
a′
b′
A
B
a″
b″
10c
15
10d
10b
44
1
42a
51
8
32
33
22
21
11
19
21
29
27
46
47
39
6
7
20
17
38
38
8
4
2
30
27
17a
18
43
13
10a
3
35
18
17
23
4
36
18
17
23
5
37
18
17
A
16
12
1
42
14
4948
25
34
50
47
32
11b
22
19
11a
26
28
38
20
9
41
27
39
31
24
23
40
45
B

Structure and Insertion.—The fibre-bundles form a fusiform belly which is inserted by a short tendon into the lower part of the tip of the transverse process of the atlas.

The obliquus capitis superior.—*Origin.*—From the back of the upper part of the transverse process of the atlas.

Structure and Insertion.—The fibre-bundles diverge to form a flat, triangular muscle, inserted into the lateral third of the inferior nuchal line of the occipital bone, and above the lateral part of the insertion of the rectus capitis posterior major.

Nerve-supply.—These muscles are all supplied by the posterior branch of the suboccipital (first cervical) nerve. The branch to the two rectus muscles passes across the dorsal surface of the major rectus and supplies branches to the middle of the dorsal surface of each muscle. The branch to the superior oblique muscle enters the middle of the medial margin, that to the inferior oblique about the middle of its superior margin.

Relations.—The two oblique muscles with the rectus major serve to bound a small triangular space, the suboccipital triangle, through which pass the dorsal division of the suboccipital nerve and the vertebral artery. The two minor recti lie on the atlanto-occipital membrane in the upper part of the space bounded by the major recti. The muscles are covered by the semispinalis capitis (complexus). In front of the two oblique muscles and the major rectus runs the vertebral artery. The great occipital nerve runs between the semispinalis capitis (complexus) and the inferior oblique and the two recti.

Action.—The rectus muscles and the superior oblique draw the head backwards. The rectus major and the inferior oblique, when acting on one side, rotate the face towards that side.

Variations.—Each of these muscles may be doubled by longitudinal division. Accessory slips may connect the two recti with the semispinalis capitis. The **atlanto-mastoid** is a small muscle frequently found. It passes from the transverse process of the atlas to the mastoid process.

IV. THE THORACO-ABDOMINAL MUSCULATURE

The intrinsic thoraco-abdominal musculature is largely covered in the thoracic region by the muscles which pass from the trunk to the arm: ventrally by the pectoral muscles, laterally by the latissimus dorsi and by the serratus anterior (magnus), which in turn is covered by the scapula and the scapulo-humeral muscles. In the abdominal region, on the other hand, it is not covered by other musculature except where the latissimus dorsi slightly overlaps it in the loin. The intrinsic muscles of the back in part extend over the thoraco-abdominal musculature (intercostals and levatores of the ribs), and in turn are in part covered by muscles which extend dorsally from the thoracic region (posterior serrati).

Belonging to the intrinsic musculature of the thoraco-abdominal wall there are in the region of the thorax the **external intercostal** muscles (fig. 346), the fibres of which run obliquely downwards and forwards between each pair of ribs, and which, dorsally are prolonged to the vertebral transverse processes as the **levatores costarum** (fig. 344); the **internal intercostal** muscles (fig. 346), the fibre-bundles of which extend obliquely downwards and backwards and in the back of the thorax are prolonged over two interspaces as the **subcostal** muscles; and the **transversus thoracis** (triangularis sterni) (fig. 347), which extends from the inner surface of the cartilages of the ribs to the sternum. The 'abdominal' musculature is in part also prolonged over the distal margin of the thorax. To it belong several muscles. The **rectus abdominis** (fig. 349) is a band-like muscle which extends on each side of the mid-ventral line from the pubis to the xiphoid process of the sternum and to the cartilage of the fifth rib. The **pyramidalis** (fig. 349) is a small muscle, extending over the rectus above the pubis. The broad, flat **external oblique** muscle (fig. 348), extends from the lower seven ribs to the crest of the ilium and through an aponeurosis to the inguinal ligament and medially across the rectus to the tendinous linea alba (fig 349), in the mid-ventral line of the body, between the two recti. The somewhat smaller and thinner **internal oblique** (fig. 349), extends from the lumbo-dorsal fascia, the crest of the ilium, and the inguinal ligament to the sheath of the rectus and to the ventral extremities of the three lower ribs. From the internal oblique the **cremaster** muscle (fig. 350) is prolonged over the spermatic cord and testis. The thin, flat **transversus abdominis** (fig. 351) extends from the cartilages of the lower seven ribs, from the lumbo-dorsal fascia, the iliac crest, and the inguinal ligament to the deep surface of the sheath of the rectus in the upper two-thirds of the abdomen and to the superficial surface in the lower third.

These muscles are supplied by the thoracic and the first lumbar nerves. The intercostal nerves likewise supply the thin, flat **posterior serratus** muscles (fig. 341), which extend from the upper and lower parts of the thoracic walls over the dorsal musculature.

The **quadratus lumborum** (fig. 353), which extends from the twelfth rib to the ilium and ilio-lumbar ligament, is supplied by direct branches of the lumbar nerves in series with the nerves supplying the musculature of the abdominal wall. It will, therefore, be taken up with this group. The psoas muscle, on the other hand, which also lies at the back of the abdominal cavity, represents an extension of the intrinsic musculature of the limb to the spinal column (see p. 425).

The **diaphragm** (fig. 352), a dome-shaped muscle which is attached to the distal margin of the thorax and to the upper lumbar vertebræ, and serves to separate the thoracic and abdominal cavities, arises in the embryo in the region of the neck, and maintains cervical relations through its innervation by the phrenic nerve, which springs usually from the fourth cervical nerve. It does not belong morphologically with the other muscles considered in this section, but is here included because of its physiological and anatomical relations and the convenience of treating it in connection with the intrinsic thoraco-abdominal muscles. A diaphragm completely separating the thoracic from the abdominal cavities is found only in the mammals.

The thoracic musculature serves mainly to enlarge the thorax, although the subcostal and transversus muscles and probably the dorsal part of the internal intercostal muscles serve to depress and contract the thorax. The abdominal muscles serve to contract both the thoracic and the abdominal cavities. The diaphragm serves to enlarge the thoracic at the expense of the abdominal cavity. The quadratus lumborum serves to bend the spine laterally and to depress the twelfth rib.

In fishes and tailed amphibians the musculature of the body wall is composed of metamerically segmented musculature. In all higher vertebrates it is likewise at an early embryonic stage segmental, being composed of the ventro-lateral portions of the myotomes. The ventral ends of the myotomes give rise to a ventral longitudinal muscle which runs on each side of the body next the mid-line in front, and retains more or less of the primitive segmentation. The rectus abdominis and the infrahyoid muscles represent this system in man. Very frequently traces of the system may also be seen on the upper thoracic wall in the form of slender muscular and aponeurotic slips. The rectus muscle in man is usually developed from the last seven thoracic myotomes. The pyramidalis becomes split off from its lower end. The lateral part of the ventro-lateral portions of the thoracic myotomes usually gives rise to several strata of muscles which vary somewhat in different vertebrates, although quite similar among the mammals. In man the twelve thoracic and first lumbar myotomes give rise to the lateral musculature of the thoraco-abdominal wall. The three chief strata are, first, an outer, the fibres of which run obliquely downwards and forwards (external intercostals, levatores costarum, external oblique); second, an intermediate, the fibres of which run obliquely downwards and backwards (internal intercostals, subcostals, and internal oblique); third, an internal, the fibres of which run transversely (thoracic and abdominal transversi). In addition, from the superficial layer there are differentiated two muscles which extend over the dorsal muscles (the posterior serrati).

The quadratus lumborum represents the ventro-lateral portions of the lumbar myotomes with the exception of that portion of the first which enters into the lateral abdominal musculature and of the fifth, which probably undergoes retrograde metamorphosis.

It will be noted that the abdominal wall is composed of musculature which has an origin chiefly from the thoracic myotomes. At an early stage of embryonic development both the thoracic and the abdominal viscera are covered by a non-muscular membrane. The myotomes extend into this from the thoracic region, and as the musculature is differentiated, it approaches the median line in front and extends distally to the pelvis. Owing to the rotation of the limb, the abdominal musculature is stretched ventrally over an area corresponding to the lumbar and sacral regions dorsally. The last part of the thoraco-abdominal wall to be furnished with musculature is that about the umbilicus. Occasionally the process fails to be completed in this region.

Each spinal nerve supplies primarily the musculature derived from the myotome which lay caudal to it, and at first the musculature lies wholly superficial to the nerves. With subsequent differentiation the metamerism is somewhat obscured by anastomosis of nerves and fusion of myotomes; and a part of the internal oblique layer and all the transverse layer of the lateral musculature comes to lie on the inner side of the main nerve-trunks.

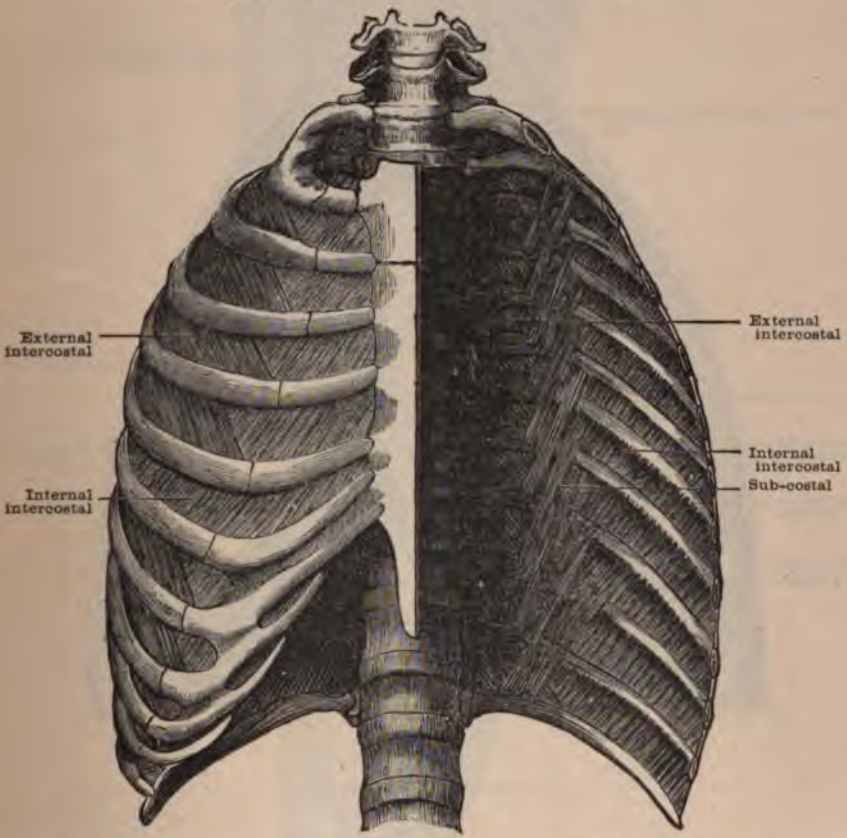
The **fasciæ** and the topographical relations of the thoraco-abdominal muscles may be followed in the sections shown in figs. 320, 345, and 354.

Tela subcutanea.—As mentioned above, most of the intrinsic thoracic musculature is covered by other muscles, while the superficial layer of the abdominal musculature is subcutaneous. A panniculus adiposus in which much fat may be deposited is here in most places easily distinguishable from a membranous fascial sheet which is loosely adherent to the underlying fascial envelopment of the muscles. To this membrane has been applied the term **Scarpa's fascia.** Near the groin it is separated from the panniculus adiposus by blood-vessels and lymphatic glands. It is closely bound to the linea alba between the two rectus muscles, to the fibrous structures in front of the pubic bone, to the fascia lata below the inguinal ligament, and to the crest of the ilium.

Over the scrotum of the male and vulva of the female both layers of the tela subcutanea are continued. In the male the fat of the more superficial layer disappears and the two layers blend with the fundiform (suspensory) ligament and fascia of the penis and the dartos and septum of the scrotum.

Muscle fasciæ and sheaths.—The posterior serrate muscles (fig. 341) are enveloped by two adherent layers of an aponeurotic sheet that extends as a single membrane between them and is attached lateralwards to the ribs and medialwards to the spines of the thoracic vertebræ. The membrane between the muscles may represent the rudiment of a primitive continuous muscle such as is found in some lower vertebrates. This membrane may usually be easily separated from the aponeurosis of the latissimus dorsi on its superficial surface and the lumbo-dorsal fascia on its deep.

Fig. 346.—The Intercostal Muscles.



The intercostal muscles are covered by delicate, adherent membranes on each surface. The external intercostal muscles are continued as aponeurotic bands between the costal cartilages. These serve here as fasciæ for the internal intercostals.

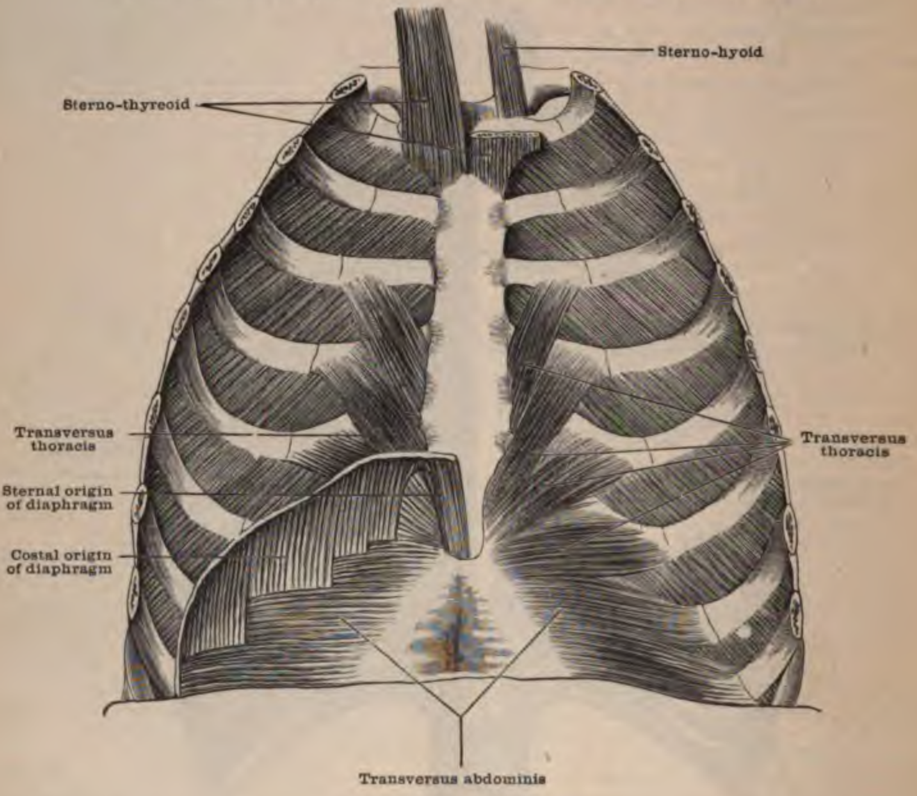
The external oblique muscle is covered externally by a dense, adherent membrane and internally by a more delicate membrane except where the muscle is attached to the ribs or fused with the external intercostal muscles. Ventrally and distally these membranes are fused beyond the fleshy portion of the muscle to the broad aponeurosis that serves to ensheath the rectus muscle and cover the lower part of the abdominal wall (fig. 350). Dorsally the membranes are in part attached to the ribs and in part are fused to form a membrane which becomes adherent to the deep surface of the latissimus dorsi in the thoracic region and to the lumbo-dorsal fascia in the lumbar.

The internal oblique muscle and the transversus abdominis have similar membranous coverings which are fused to the aponeuroses of origin and insertion of these muscles. The membranes on the muscles are, however, much more delicate than that of the external oblique. More or less fusion between the two muscles with disappearance of the membranes covering the opposing surfaces takes place, especially in the lower part of the abdominal wall.

The diaphragm is covered on each surface by a more or less well-marked adherent membrane.

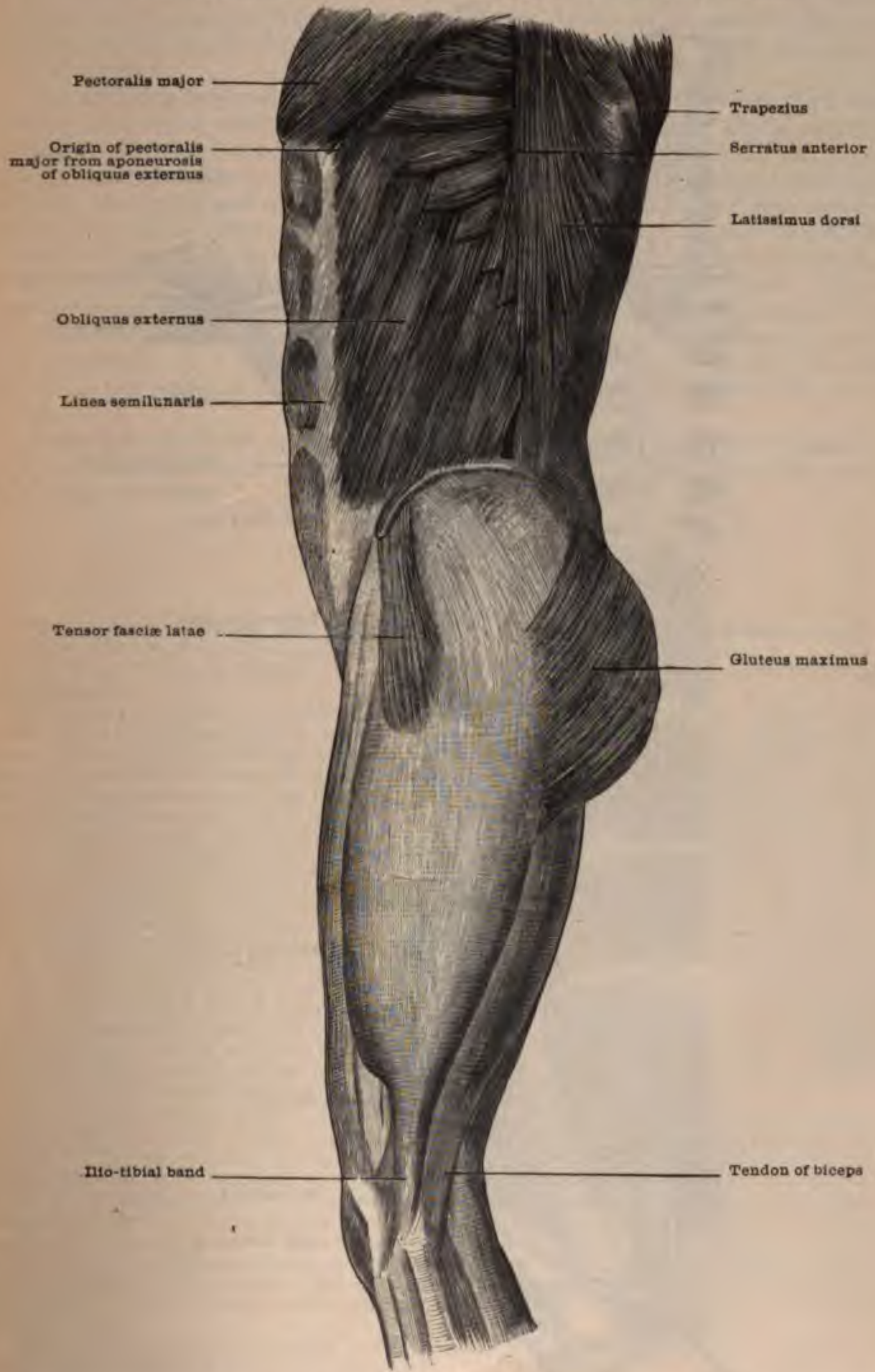
The **transversalis fascia** is a thin membrane which lies external to the peritoneum of the abdominal wall. It covers the peritoneal surface of the transversus muscle and its aponeurosis. Ventrally it is continued across the median line internal to the rectus abdominis. In the lumbar region the fascia divides at the lateral margin of the quadratus lumborum (fig. 345), one lamina of it passing dorsal to this muscle to be attached to the lumbo-dorsal fascia. The other lamina extends over the ventral surface of the quadratus and becomes fused with the psoas fascia. Proximally the transversalis fascia becomes fused with the fascial membrane adherent to the diaphragm. In the region of the iliac fossa the transversalis fascia is reflected from the transversus muscle to the ilio-psoas fascia, with which it usually becomes fused. Sometimes, however, it may be traced as a very delicate membrane over the iliac artery and vein. As these vessels pass below the inguinal ligament a process from the transversalis fascia is usually reflected into their sheath.

FIG. 347.—THE MUSCLES ATTACHED TO THE BACK OF THE STERNUM.



The **sheath of the rectus** (figs. 345, 354) is formed externally in the upper portion of its extent by the aponeurosis of the external oblique which fuses distal to the costal margin with the external layer of the aponeurosis of the internal oblique. In the lower third of its extent the rectus is covered ventrally by the fused aponeuroses of the two oblique muscles conjoined with that of the transversus. Internally the rectus is covered in the upper two-thirds of the abdomen by the inner layer of the aponeurosis of the internal oblique conjoined with that of the transversus and by the transversalis fascia. In the lower third of the abdomen the aponeurosis of the internal oblique, together with that of the transversus, passes in front of the rectus, leaving the rectus in this portion of its abdominal surface covered merely by the transversalis fascia and the peritoneum. The line which marks the lower limit of

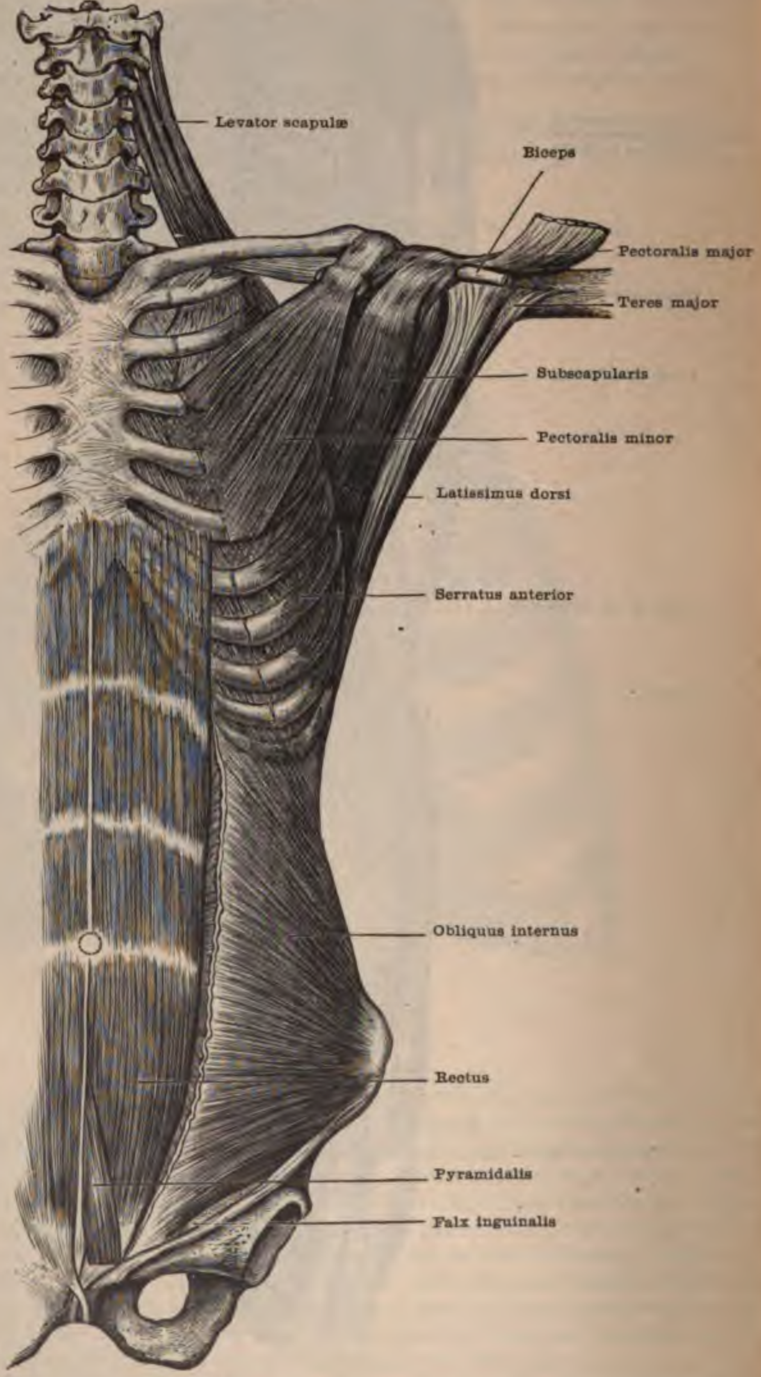
Fig. 348.—Superficial Musculature of Abdomen and Thigh.


Pectoralis major
Origin of pectoralis major from aponeurosis of obliquus externus
Obliquus externus
Linea semilunaris
Tensor fasciæ latae
Ilio-tibial band
Trapezius
Serratus anterior
Latissimus dorsi
Gluteus maximus
Tendon of biceps

the dorsal ensheathment of the rectus by the aponeurosis of the transversus muscle is called the **linea semicircularis,** or fold of Douglas.

The pyramidalis lies between two layers of the sheath of the rectus.

FIG. 349.—THE PECTORALIS MINOR, OBLIQUUS INTERNUS, PYRAMIDALIS, AND RECTUS ABDOMINIS.


Levator scapulæ
Biceps
Pectoralis major
Teres major
Subscapularis
Pectoralis minor
Latissimus dorsi
Serratus anterior
Obliquus internus
Rectus
Pyramidalis
Falx inguinalis

Between the rectus muscles of each side the investing aponeuroses are firmly united into a dense tendinous band, the **linea alba** (fig. 349). This is broadest opposite the umbilicus. Above this it gradually grows narrower towards the xiphoid process to the ventral surface of which it is attached. From the tip of the xiphoid process it is often separated by a bursa. Towards the symphysis pubis it extends as a narrow line. Just above the symphysis, to which it is attached dorsally and ventrally, it broadens into the **adminiculum lineæ albæ.** The linea alba is composed mainly of the interlacing of the fibres which pass into it from the aponeurotic sheaths of the rectus abdominis. From it, a few centimeters above the symphysis, there arises a broad elastic band, the **fundiform ligament** (suspensory ligament) of the penis, which sends a fasciculus on each side of the penis. Below the penis these fasciculi unite.*

The **anterior layer** of the **lumbo-dorsal fascia** and its relations to the abdominal muscles also merit attention. This lies between the intrinsic dorsal musculature and the quadratus lumborum muscle and extends from the twelfth rib to the ilio-lumbar ligament. It is strengthened by the lumbo-costal ligament which extends between the transverse processes of the first and second lumbar vertebræ and the twelfth rib, and by fibrous processes which extend into it from the transverse processes of the lumbar vertebræ to which it is attached. With the lateral margin of this anterior layer the posterior layer of the lumbo-dorsal fascia is fused. The dorsal aponeurosis of the transversus muscle is united to the lumbo-dorsal fascia at the line of junction of the anterior and posterior layers. The internal oblique muscle, covered externally by a fascia continued dorsally from the external oblique, arises in part from the posterior layer of the lumbo-dorsal fascia near the junction of the two layers.

The relations of the aponeuroses of the oblique and transversus muscles to the inguinal canal are described in connection with those muscles and in the section on SURGICAL ANATOMY.

MUSCLES

A. VENTRAL DIVISION

The rectus abdominis (fig. 349).—*Origin.*—Ventral surface of the fifth to seventh costal cartilages, the xiphoid process, and the costo-xiphoid ligament.

Insertion.—The upper border of the superior ramus of the pubis and the ventral surface of the symphysis.

Structure.—The muscle is long, flat, and somewhat triangular in form. Cranialwards it is broad and thin; caudalwards it becomes thicker as it converges towards the insertion. The fibre-bundles of the muscle have a longitudinal course. It is crossed by several incomplete, zigzag, transverse tendinous bands, **inscriptiones tendineæ,** better developed on the ventral than on the dorsal surface of the muscle. One of these, corresponding segmentally to the tenth rib, is usually situated opposite the umbilicus. Another, corresponding to the ninth rib, is situated midway between this and the distal margin of the thoracic wall, and one corresponding to the seventh rib is found at the level of the distal margin. Between this and the one corresponding to the ninth rib an additional inscription is frequently found. Distal to the umbilicus an inscription corresponding with the eleventh rib is often found (30 per cent.). In these inscriptions many of the fibre-bundles have their origin and insertion. The thoracic attachments take place by means of band-like fasciculi which extend upwards from the highest inscription, the fibre-bundles of these fasciculi being inserted by short tendinous bands. The pubic attachment of the muscle takes place by a short, thick tendon, usually divisible into two portions, of which the broader, lateral portion is inserted into a rough area extending from the pubic tubercle (spine) to the symphysis, while the more slender medial portion is attached to the fasciæ in front of the symphysis pubis, where its fibres interdigitate with those of the opposite side. In addition to the attachments mentioned, some of the fibre-bundles are attached to the sheath of the rectus and many, after interdigitating, terminate in the intramuscular framework.

Nerve-supply.—The anterior branches of the six or seven more distal intercostal nerves enter the deep surface of the muscle near its lateral edge. The cutaneous branches pass obliquely through its substance, while the muscular branches give rise to an intramuscular plexus. As a rule, the chief ventral branch of the tenth thoracic nerve enters the substance of the muscle slightly distal to the umbilical transverse inscription. The branches of the eleventh and twelfth nerves enter more distally. The main branch of the ninth nerve enters slightly distal to the preumbilical inscription; the eighth nerve, between this and the distal margin of the thorax. Either the sixth or seventh nerve may supply the fasciculi of origin. In addition to the main branches other smaller branches of the nerves of the abdominal wall are also usually distributed to the muscle. Each segment, either directly or through intramuscular plexuses, has a supply from more than one spinal nerve.

Action.—To depress the thorax and flex the spinal column. When the thorax is fixed the rectus serves to flex the pelvis upon the trunk.

Relations.—It lies between the transversalis fascia and the tela subcutanea and is ensheathed by the aponeuroses of the lateral abdominal muscles, as above described. The epigastric artery runs on its deep surface.

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*Alex. Hagenton has shown that the linea alba varies much in width. It is relatively wide in fat people and in fœtuses.

Variations.—The rectus muscle varies in the number of its tendinous inscriptions and in the extent of its thoracic attachment. It may extend farther than usual on the thorax. Frequently aponeurotic slips or slips of muscle on the upper part of the thorax indicate a more primitive condition in which the muscle extended to the neck. Absence of a part or the whole of the muscle has been noted. The muscles of the two sides may be separated by a considerable interval in the neighbourhood of the umbilicus. The muscle is relatively thicker in men than in women.

The pyramidalis (fig. 349).—*Origin.*—Ventral surface of the superior pubic ramus.

Structure and Insertion.—The fibre-bundles extend towards and are inserted into the linea alba for about a third of the distance to the umbilicus, and give rise to a flat, triangular belly.

Nerve-supply.—Usually through a branch of the twelfth thoracic, which extends into the muscle from the rectus abdominis. Not infrequently a special branch extends into the muscle from the ilio-hypogastric or ilio-inguinal.

Action.—To draw down the linea alba in the median line.

Relations.—It lies between two laminæ of the anterior layer of the sheath of the rectus.

Variations.—It is missing in about 16 per cent. of instances (Le Double). Dwight has found it absent in 81 out of 450 males and in 60 out of 223 females dissected at the Harvard Medical School. It may extend upwards to the umbilicus or be but very slightly developed. It may be double. In many of the mammals it is missing. It is well developed in the marsupials and monotremes.

B. Lateral Division

1. *Serratus Group* (fig. 341)

The serratus posterior superior.—*Origin.*—By a broad, thin aponeurosis from the ligamentum nuchæ and the spines of the last one or two cervical and the first two or three thoracic vertebræ.

Structure and Insertion.—The fibre-bundles take a nearly parallel course downwards and lateralwards and give rise to a flat belly which ends by four fasciculi on the upper margin of the second to the fifth ribs, lateral to the ilio-costalis.

Nerve-supply.—Through branches from the first four intercostal nerves. These nerves give rise to a plexus which passes across the deep surface of the muscle in the middle third between the tendons of origin and insertion.

Action.—To elevate the ribs to which the muscle is attached, and through them to enlarge the thorax.

Relations.—It lies upon the wall of the thorax and the intrinsic dorsal musculature and beneath the levator scapulæ, rhomboids, and trapezius. Its fasciculi extend on the ribs to those of the serratus anterior (magnus).

The serratus posterior inferior.—*Origin.*—Through an aponeurosis, fused medially and distally with the lumbo-dorsal fascia, from the last two or three thoracic and first two or three lumbar spines.

Structure and Insertion.—From the aponeurosis arise four flat bands which are successively attached to the inferior margins of the last four ribs, lateral to the ilio-costalis.

Nerve-supply.—From the last four intercostal nerves arise branches which form a plexus that extends across the deep surface of the muscle in the middle third between the tendons of origin and insertion.

Action.—To depress and draw outwards the four lower ribs and through them to enlarge the thorax. Together with the serratus posterior superior and the connecting aponeurotic fascia it aids in keeping the intrinsic dorsal muscles in place.

Relations.—It lies upon the intrinsic dorsal musculature, the lower dorsal part of the thorax, and the lumbo-dorsal fascia, and beneath the latissimus dorsi, the trapezius, and their aponeuroses.

Variations.—The fasciculi of both muscles vary in number and may be replaced by aponeurotic slips. Aberrant muscle fasciculi may be found in the fascia which connects the two muscles. In several of the lower mammals the two muscles are normally continuous.

2. *External Oblique Group*

The intercostales externi (fig. 346).—These muscles extend in the intercostal spaces from the tubercles of the ribs to the costal cartilages. The more distal muscles often, however, do not quite reach the cartilages. The first intercostal muscle may extend to the sternum. The others are continued through the intercostal region by thin aponeuroses, the **external intercostal ligaments**, the fibres of which have a direction corresponding to that of the muscle fibre-bundles. Dorsally the muscles are fused with the levatores, and ventrally the lower seven muscles are more or less fused wth the corresponding fasciculi of the external oblique.

Origin.—From the lower margin of each rib external to the costal sulcus.

Structure and Insertion.—The fibre-bundles take a parallel course obliquely forwards and downwards to the upper margin of the next rib. The proximal fibre-bundles are more oblique than the distal, and the muscles are best developed in the dorsal part of the intercostal spaces.

Nerve-supply.—By several branches from the corresponding intercostal nerves.

Action.—To elevate the ribs and enlarge the thorax.

Relations.—They are covered externally by the pectoral muscles, the serratus anterior, and serrati posteriores, the levatores costarum, the sacro-spinalis (erector spinæ), and the external oblique muscles. Internally they are separated by a slight amount of loose tissue from the internal intercostals, the membranes which continue these muscles medially, and from the subcostal muscles.

Variations.—When the twelfth rib is very small or is lacking, the eleventh intercostal muscle may be missing. When there is a supernumerary cervical or thirteenth thoracic rib, there may be an extra external intercostal muscle. Next to the first intercostal, the fourth most frequently reaches the sternum.

The levatores costarum (fig. 344).—These consist of a series of flat, triangular muscles, each of which *arises* from the tip and inferior margin of a transverse process and extends laterally outwards with diverging fibre-bundles to be *inserted* into the dorsal surface of the rib below, from the tubercle to the angle. The first extends from the transverse process of the seventh cervical vertebra to the first rib. They increase successively in size from this to the last, which is attached to the twelfth rib. Those arising from the transverse processes of the eighth to the eleventh thoracic vertebræ send their more medial fibre-bundles across the rib below to join the lateral margin of the succeeding muscle (**levatores longi**). The levatores costarum are closely united to the external intercostals and are innervated by the intercostal nerves which pass forwards in the corresponding intercostal spaces.

Action.—To bend laterally and extend the spinal column.

Relations.—They are covered dorsally by the longissimus dorsi.

Variations.—The first levator may be continued into the scalenus posterior. When greatly developed, the series of levators forms a serrate muscle.

The obliquus abdominis externus (fig. 348).—*Origin.*—By eight fleshy digitations from the external surface of the lower eight ribs immediately lateral to where they join the cartilages. The first five slips interdigitate with the serratus anterior (magnus), the last three with the latissimus dorsi.

Insertion.—(1) By a strong aponeurosis which extends over the rectus to the linea alba, where the more superficial fibres interdigitate across the median line, and to the inguinal (Poupart's) ligament; and (2) directly into the outer lip of the crest of the ilium. The aponeurosis over the rectus is usually partly fused with the aponeurosis of the internal oblique.

Structure.—The fibre-bundles which compose the flat fasciculi of origin diverge slightly as they pass forwards and downwards, and by fusion of their edges give rise to a flat sheet of muscle. The fasciculus taking origin from the fifth rib passes nearly directly ventrally, but the succeeding fasciculi take a more distal direction, those from the seventh to the ninth ribs showing the greatest distal expansion. The lower margin of the fasciculus which arises from the seventh rib terminates opposite the umbilicus, that from the ninth rib extends towards the anterior superior spine of the ilium, and those from the last three ribs descend to the iliac crest. The first two fasciculi extend over the lateral margin of the rectus, the next two to its lateral edge. The fourth and fifth usually terminate along a line extending ventrally from the anterior superior iliac spine towards the rectus.

The **inguinal ligament** (Poupart's ligament) (figs. 348, 350, 351) is a strong band which extends along the distal margin of the aponeurosis from the anterior superior iliac spine to the pubic tubercle. Distally the fascia lata of the thigh is attached to it, and internally the deeper abdominal muscles in part arise from it. Medially near the attachment of the ligament to the pubic tubercle (spine) diverging fibres are given off which pass to the pecten (crest) of the pubis and give rise to the triangular lacunar ligament (Gimbernat's ligament). This is fused with the fascia of the pectineus muscle and bounds the femoral ring. Above the inguinal ligament near its medial extremity lies the external opening of the inguinal canal, the **subcutaneous inguinal ring.** This opening is formed by the diverging of the lower medial fibres which compose the aponeurosis of the external oblique muscle. The superior fibres form the upper boundary, superior **crus,** of the ring and pass to the front of the symphysis pubis. The inferior fibres form the inferior boundary, **inferior crus,** of the ring and pass to the pubic tubercle (spine). Between these two fibre-bands **intercrural** (intercolumnar) **fibres** arch about the lateral boundary of the ring and serve to strengthen the anterior and inferior walls of the inguinal canal. From the inguinal ligament beneath and medial to the ring there arises a fibrous band, the **reflected inguinal ligament** (Colles' ligament; triangular fascia), which passes medially and upwards behind the superior crus to become fused with the anterior layer of the sheath of the rectus muscle.

Nerve-supply.—The external oblique is supplied by rami from the lateral branches of the lower seven intercostal nerves and usually from the ilio-hypogastric as well. The rami of the first two or three nerves usually extend on the external surface of the muscle, while the others extend to the deep surface of the muscle as the cutaneous branches are passing through it towards the skin. The nerves of the external oblique take a more transverse direction than the fasciculi of the muscle. Thus the branch from the tenth intercostal nerve extends towards the umbilicus and that of the twelfth towards a point midway between the umbilicus and the symphysis pubis. The nerves have a segmental distribution corresponding with the primitive segmental condition of the muscle.

Action.—(1) To compress the abdomen; (2) to depress the thorax; (3) to flex the spinal column; and (4) to rotate the column towards the opposite side. With the thorax fixed it serves to flex and rotate the pelvis.

Relations.—It lies superficial to the lower ventro-lateral margin of the thorax and the internal oblique muscle. It is partly covered by the latissimus dorsi muscle behind. Otherwise it is subcutaneous.

Variations.—It may have a more or less extensive origin from the ribs. Broad fasciculi not infrequently are separated by loose tissue from the main belly of the muscle either on its deep or superficial surface. Occasionally tendinous inscriptions are found. These transverse inscriptions are constant in many of the smaller mammals. The **supracostalis** is a rare fasciculus which runs on the thoracic wall from the sternum to the insertion of the scalenus posterior. It is usually supplied by branches of the upper thoracic nerves and seems to be a continuation upwards of the external oblique muscle.

3. *Internal Oblique Group*

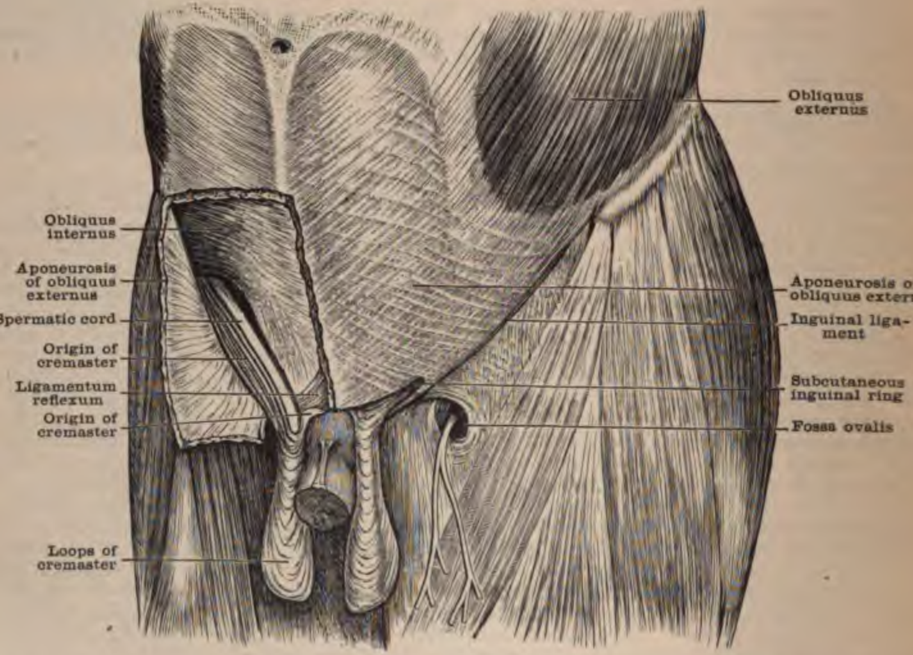
The intercostales interni (figs. 346, 347, 349).—These extend in the intercostal spaces from the angles of the ribs to the sternal ends of the spaces. The upper and lower muscles are usually continued dorsally slightly beyond the angles of the ribs. Dorso-medially the internal intercostals are continued in the form of a thin fascial sheet across the inner surface of the external intercostals and become fused with the subcostals.

Origin.—Near the angles of the ribs they arise from the internal lip of the costal sulcus. More ventrally they arise mainly from the external lip of the sulcus, but also in part from the internal lip.

Structure and Insertion.—The fibre-bundles take a parallel course downwards and dorsalwards to the upper margin of the rib below. They are less obliquely placed than those of the external intercostals. The muscles are thicker in front and grow thinner dorsally. They contain less fibrous tissue than the external intercostals.

Nerve-supply.—From numerous branches of the corresponding intercostal nerves.

FIG. 350.—STRUCTURES OF INGUINAL REGION.



Action.—Investigators disagree as to the functions. It is probable that the portions of the muscles between the ribs serve to contract, those between the costal cartilages to expand, the thorax.

Relations.—Between the ribs they are covered by the external intercostal muscles and between the costal cartilages by the external intercostal ligaments. Between the internal and external muscles there is some loose areolar tissue. Proximally, for a short distance, the intercostal nerve in each interspace runs between the external and internal intercostal muscles, but more distally it runs first in the substance of and then on the internal surface of the internal intercostal. The terminal branches of the first six nerves, however, pass through the muscle on their way to the skin, while the last six pass beneath the inferior margin of the thorax. Internal to the internal intercostal muscles lie the transversus (triangularis sterni) and subcostal muscles, the diaphragm, and the pleural membranes. The more distal internal intercostal muscles are continuous with the internal oblique and the subcostal muscles.

Variations.—The tenth and eleventh internal intercostal muscles normally are but slightly developed and often may be wanting. The internal intercostals of the first three spaces may extend to the vertebræ.

The subcostales (fig. 346).—These muscles are due to an extension over two or more intercostal spaces of those fibre-bundles of the internal intercostal muscles which lie in the proximal part of the interspaces. They arise near the angles of the ribs, and are usually well developed only in the lower part of the thorax. The component fibre-bundles keep the general direction of the internal intercostals, but they converge towards the tendons of insertion, which are attached in each case to the second or third rib below, between the angle and the neck.

Nerve-supply.—The main nerve of supply for each muscle comes from the intercostal nerve running below the rib from which the muscle takes origin.

Action.—To depress the ribs and contract the thorax.

Relations.—They lie on the inner side of the internal and external intercostals and the ribs, and are covered by the pleural membranes.

Variations.—They vary much in development and are only rarely found in the upper portion of the thorax.

The obliquus abdominis internus (fig. 349).—*Origin.*—From the lumbo-dorsal fascia the intermediate lip of the ventral two-thirds of the iliac crest, and the lateral two-thirds of the inguinal ligament.

Structure and Insertion.—From the origin the fibre-bundles radiate forwards in a flat sheet. The most dorsal extend to the lower three ribs, where they become continuous with the internal intercostals. The rest extend towards the lateral margin of the rectus, the upper ones towards the ensiform process, the intermediate towards the umbilicus, the lower ones somewhat obliquely downwards across the lower part of the abdomen. The fibre-bundles which extend towards the rectus terminate in an aponeurosis which in its upper two-thirds divides into two layers, one of which passes in front of and the other behind the rectus muscle to the linea alba. In the lower third the aponeurosis passes as a single membrane in front of the rectus. In the neighbourhood of the subcutaneous inguinal (external abdominal) ring the muscle is continued into the cremaster. Medial to the ring some fasciculi are attached to the tubercle of the pubis and to the symphysis.

Nerve-supply.—From branches of the last three intercostal and the ilio-hypogastric and ilio-inguinal nerves as these pass between this muscle and the transversus.

Action.—To depress the thorax, flex the spine, and bend and rotate it towards the side on which the muscle is placed. When the thorax is fixed, the muscle serves to flex and rotate the pelvis.

Relations.—It lies between the external oblique and the transversus. The **trigonum lumbale** (triangle of Petit) is an area, variable in size, between the posterior margin of the external oblique, the lateral margin of the latissimus dorsi, and the crest of the ilium. In this area the internal oblique is subcutaneous.

Variations.—The attachments and the extent of development of the fleshy part of the muscle vary considerably. Occasionally tendinous inscriptions are found in the muscle which indicate a primitive segmental condition.

The cremaster (fig. 350).—The cremaster muscle is found only in the male. It represents an extension of the lower border of the internal oblique muscle over the testis and spermatic cord.

Origin.—(1) Lateral, thick and fleshy, from about the middle of the upper border of the inguinal ligament, and (2) medial, thin and tendinous, from the sheath of the rectus muscle and the tubercle (spine) of the pubis.

Structure.—The lateral head is applied to the lateral side, the medial head to the medial side, of the spermatic cord. Both pass with this through the subcutaneous (external abdominal) ring of the inguinal canal and become spread in loops over the testis. Ensheathing the muscle and between the somewhat scattered fibre-bundles which compose it, there extends a thin, membranous layer of connective tissue, the **cremasteric (Cowper's) fascia.**

Nerve-supply.—The genital nerve (external spermatic), usually joined by a ramus from the inguinal nerve, gives rise to branches which spread over the muscle.

Action.—To lift the testicle towards the subcutaneous inguinal (external abdominal) ring.

Relations.—It is covered by the aponeurosis of the external oblique, the cremasteric fascia, the dartos, and the skin. It covers the spermatic cord and the testicle.

Variations.—In the female the muscle is represented by a few fasciculi on the round ligament. It may arise wholly from the transversalis fascia or be somewhat fused with the transversus muscle. The latter condition is especially frequent in muscular individuals.

4. *Transversus Group*

The transversus thoracis (triangularis sterni) (fig. 347).—*Origin.*—By aponeurotic bands from the dorsal surface of the lower half of the body of the sternum and the xiphoid process.

Structure and Insertion.—The muscle is composed of several flat, thin fasciculi, partly fibrous, more or less isolated, which are inserted by aponeurotic bands into the dorsal surface of the cartilages of the second or third to the sixth ribs, and occasionally also into the tips of the bony portions of the ribs.

Nerve-supply.—By rami from the ventral portions of the corresponding intercostal nerves. These nerves give rise to a longitudinal plexus across the deep surface of the muscle near the middle of the constituent fasciculi.

Action.—To depress the ribs in expiration.

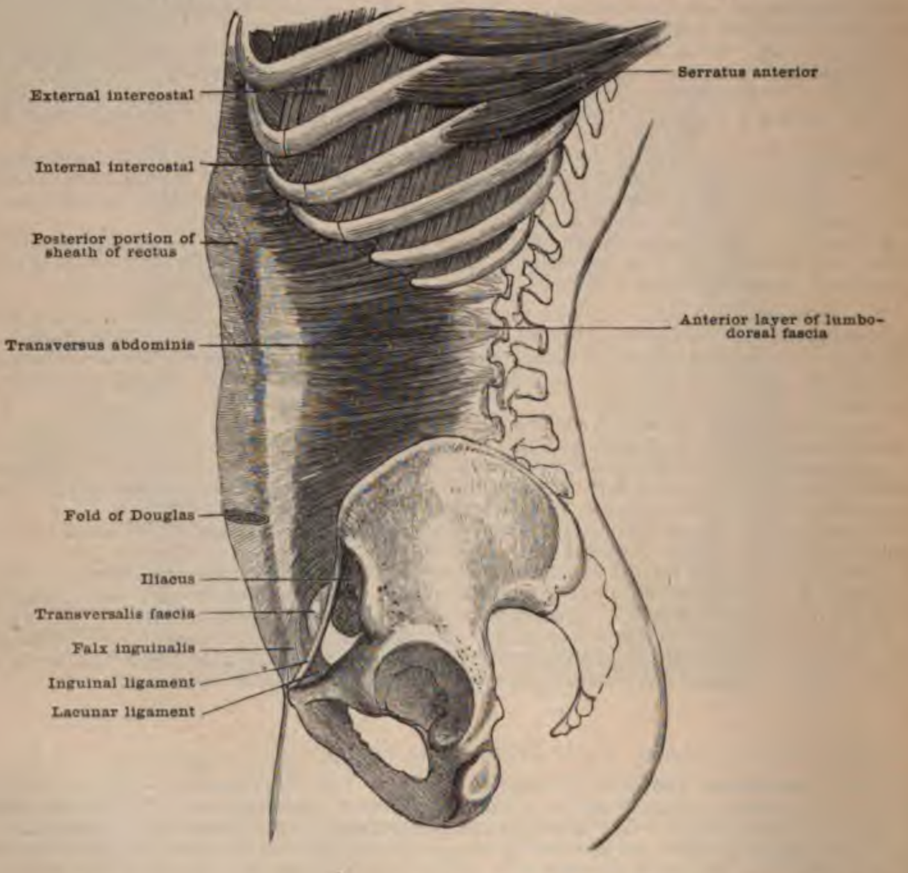
Relations.—The sternum, the costal cartilages, internal intercostal muscles, and the internal mammary vessels lie in front and the pleura and pericardium behind the muscle.

Variations.—It is an exceedingly variable muscle, both in the extent of its attachments and in the development of the individual fasciculi. The fasciculi vary in number from one to six.

The transversus abdominis (figs. 347, 351).—*Origin.*—Directly from—(1) the inner side of the cartilages of the lower six ribs by dentations which interdigitate with the attachments of the diaphragm; (2) the internal lip of the iliac crest and lateral half of the inguinal ligament; and (3) through an aponeurosis from the lumbo-dorsal fascia.

Structure and Insertion.—The fibre-bundles give rise to a broad, thin belly and take a nearly transverse course across the inner side of the abdominal wall. The most distal fibres, however are inclined obliquely towards the pubis. The fleshy portion of the muscle terminates in a strong aponeurosis along a curved line, which extends above well under the rectus and emerges lateral to the rectus opposite the umbilicus, whence it extends towards the middle of the inguinal ligament. In the upper two-thirds of the abdomen the aponeurosis extends behind the rectus to the linea alba and fuses with the inner lamina of that of the internal oblique. In the lower third of the abdomen it extends in front of the rectus to the linea alba, and is here also fused with the aponeurosis of the internal oblique. Some of the fibres are continued into the aponeurosis of the muscle of the opposite side. Distally the attachment of the muscle is somewhat more complex. The fibre-bundles here bend around the spermatic cord, on the medial side of which they are spread out to be attached to the inguinal ligament, the pubis, and the sheath of the rectus. The attachment to the inguinal ligament takes place by means of an aponeurotic band, the more lateral fibres of which are dense and curve below the spermatic cord to the inguinal ligament. This band is called the **interfoveolar ligament.** It is composed partly of bundles of fibres prolonged from the aponeurosis of the opposite transversus, and bounds the inguinal ring medially and below. Medially the transversus is united to the upper part of the os pubis, and to the sheath of the rectus by an aponeurotic band, the **falx inguinalis** (conjoined tendon). Between the interfoveolar ligament and the falx inguinalis the transversalis fascia forms the posterior wall of the inguinal canal. In this area a detached band of muscle-fibres is sometimes found. This is called the **musculus interfoveolaris.**

FIG. 351.—TRANSVERSUS ABDOMINIS AND SHEATH OF RECTUS.



Nerve-supply.—The transversus is supplied with nerves by the last five or six thoracic and the ilio-hypogastric and the inguinal nerves as these course forwards between this muscle and the internal oblique.

Action.—The chief function is to compress the abdominal viscera. Through the portions extending between the distal margins of the thorax on each side it serves to contract the thorax and so may aid in expiration.

Relations.—It lies on the inner side of the lower ribs, the internal oblique and rectus muscles, and is covered on the deep surface by the transversalis fascia.

Variations.—It is very rarely absent. It shows considerable variation in the extent of its development. The **pubo-peritonealis** is a small muscle which may pass from the pubic crest to the transversus near the umbilicus. The **pubo-transversalis** is a small muscle which may extend from the superior ramus of the pubis to the transversalis fascia near the abdominal inguinal ring. The **tensor laminæ posterioris vaginæ musculi recti abdominis** is a slender fasciculus which may extend from the inguinal ligament to the rectus sheath on the deep surface of the rectus muscle near the umbilicus. The **tensor laminæ posterioris vaginæ musculi recti et fasciæ transversalis abdominis** extends from the transversalis fascia near the abdominal inguinal ring to the fold of Douglas.

C. LUMBAR MUSCLE

The quadratus lumborum (fig. 353).—*Origin.*—From—(1) the internal lip of the iliac crest near the junction of the middle and dorsal thirds, and the iliolumbar ligament; (2) the transverse processes of the three or four lower lumbar vertebræ; and (3) the lumbo-dorsal fascia.

Structure and Insertion.—From the areas of origin there arises a complex quadrangular muscle belly from which spring the fasciculi of termination. These extend to—(1) the transverse processes of the upper three or four lumbar vertebræ; (2) to the fibre-bands which extend out laterally in the lumbar fascia from the transverse processes; and (3) to the medial part of the lower border of the twelfth rib.

Nerve-supply.—Through direct branches from the first three or four lumbar nerves.

Action.—It serves primarily to produce lateral flexion of the spinal column. When both muscles act together, they produce extension of the spine. The muscle also serves to depress and fix the twelfth rib.

Relations.—It rests posteriorly on the lumbo-dorsal fascia and the transverse processes of the lumbar vertebræ. Its medial edge is partly covered by the psoas. In front of it also lie the kidney, the intestines, and the lumbar arteries and nerves. It is ensheathed by membranes continued over each surface from the transversalis fascia. Of these, the anterior is the better marked and is called the **lumbar fascia.**

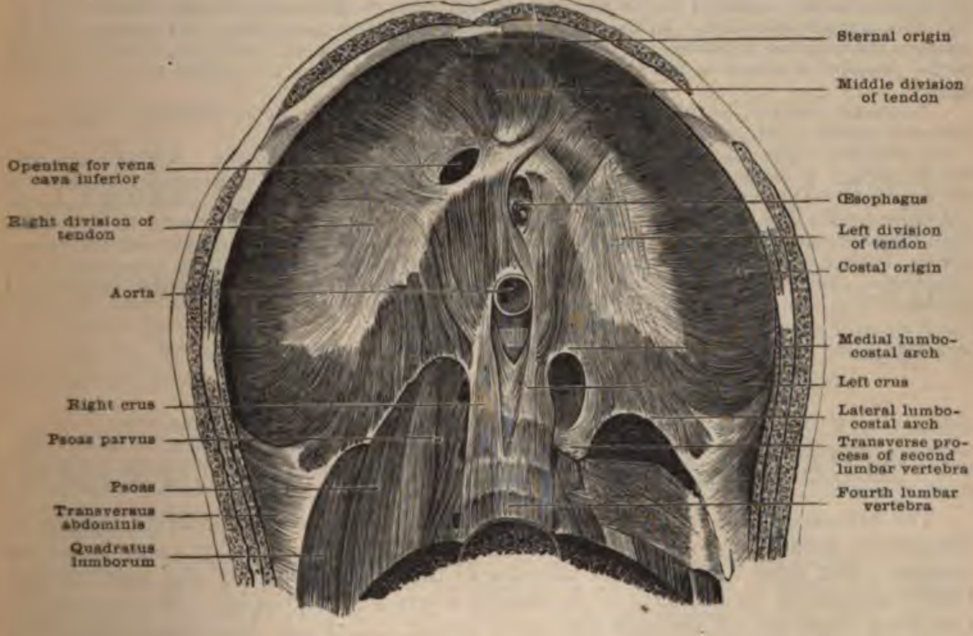
Variations.—There is much individual variation in the internal structure of the muscle and in its attachments. Its insertion may extend to the eleventh rib.

The **psoas major** and **minor** belong essentially to the musculature of the posterior limb and are there described (p. 426).

D. THE DIAPHRAGM

The Diaphragm (figs. 347, 352).—This dome-shaped musculo-membranous sheet has, when seen from above, something of the outline of a kidney. It consists of a pair of muscles which arise one on each side from the thoracic wall and are inserted into a central tendon. Lateral to the tendon the diaphragm projects higher into the thoracic cavity than in the central area. On the right, in moderate expiration, it extends in adults to the height of the medial extremity of the cartilage of the fourth rib, and on the left to that of the fifth.

FIG. 352.—DIAPHRAGM.


Sternal origin
Middle division of tendon
Opening for vena cava inferior
Œsophagus
Right division of tendon
Left division of tendon
Costal origin
Aorta
Medial lumbo-costal arch
Left crus
Right crus
Lateral lumbo-costal arch
Psoas parvus
Transverse process of second lumbar vertebra
Psoas
Fourth lumbar vertebra
Transversus abdominis
Quadratus lumborum

Origin.—On each side from—(1) the lower border and back of the xiphoid process and the adjacent aponeurosis of the transversus abdominis (*sternal portion*); (2) the lower border and inner surfaces of the cartilages and osseous extremities of the last six or seven ribs (*costal portion*); and (3) from the lumbar vertebræ (*lumbar portion*). The lumbar portion is divided somewhat irregularly into three crura, between which pass blood-vessels and nerves.

The **lateral crus** arises from the lateral surface of the bodies of the first two lumbar vertebræ and from fibrous thickenings of the fascia over the psoas and quadratus lumborum muscles. Of these, one, the **medial lumbo-costal arch** (internal arcuate ligament), extends from the second lumbar vertebra to the transverse processes of the first and second vertebræ; the other, the **lateral lumbo-costal arch** (external arcuate ligament), extends from the first or second lumbar vertebra to the twelfth rib. The lateral crus is only inconstantly attached to this. The **intermediate crus** arises from the ventro-lateral surface of the bodies of the second and third lumbar vertebræ. The **medial crus** arises from the front of the bodies of the third and the fourth lumbar vertebræ. On the left side it usually extends only to the third vertebra, and it does not always extend to the fourth on the right. The extremity and medial margin of this crus are tendinous, the lateral portion fleshy. On the second, third, and fourth, and the lower part of the first lumbar vertebræ the medial crus of each side is separated from its fellow by the **hiatus aorticus** (for the aorta and thoracic duct). Over the first lumbar vertebra they are fused by a process which extends from the right crus into the lower ventral surface of the left. Above here the right crus may be divided into two parts, one of which, fused with the left crus, passes on the left of the **hiatus œsophageus,** while the other passes on the right. More often the hiatus œsophageus lies between the right and left crura. Frequently the left crus gives off a slip which passes to the ventral surface of the right below the hiatus.

The **costal portion** arises by a series of dentations which do not correspond perfectly in number with the ribs. Some costal cartilages have two dentations attached to them. It interdigitates with the transversus abdominis.

Structure and Insertion.—The central tendon has somewhat the shape of a trifoliate leaf, the place of the stem being taken by the region occupied by the vertebral column, one leaflet lying on each side of this and one in front. The ventral part is usually placed somewhat to the left and is more or less completely fused with the left leaflet. Between the ventral and the right leaflets there is a large opening through which passes the inferior vena cava, the **foramen venæ cavæ.** The leaflets are fused in front and behind this.

The fleshy portion of the muscle is composed of fibre-bundles which pass at first nearly vertically upwards and then arch over to be attached to the margins of the central tendon. The sternal portion of the muscle is the shortest. It is often separated from the costal portion by a small space through which the superior epigastric vessels pass.

Nerve-supply.—From the phrenic nerves, one of which arises on each side from the fourth cervical nerve. Each nerve penetrates the diaphragm lateral to the central tendon and breaks up into an extensive plexus on the inferior surface of the muscle. Some of the lower intercostal nerves also contribute to the sensory innervation of the margin of the muscle and possibly also slightly to the motor innervation. The sympathetic nerves furnish fibres for the blood-vessels.

Action.—To enlarge the thoracic cavity and thus cause inspiration. The middle part of the central tendon is united to the pericardium and through this to the cervical fascia, and is, therefore, not very movable. In the contraction of the muscle it is the dorsal and lateral portions which in the main are flattened. The diaphragm aids in defecation and parturition and vomiting, by the pressure it exerts on the abdominal viscera. It also acts as a constrictor of the œsophagus.*

Relations.—Above lie the heart and the lungs; below lie the liver, stomach, duodenum, pancreas, spleen, kidneys, and suprarenal bodies.

Variations.—The sternal portion of the muscle is frequently absent. Not infrequently the diaphragm is incompletely developed dorsally on the left side. This condition is rarer on the right side. The extent of the various insertions of the diaphragm shows considerable individual differences. The vertebral portion of the muscle may be slightly fused with the psoas or with the quadratus lumborum. Some fusion of the ventral portion of the muscle with the transversus thoracis has also been seen. Small fasciculi may pass to neighbouring structures: the œsophagus, stomach, liver, mesentery, etc. Muscle fasciculi are frequently found in the central tendon.

V. MUSCULATURE OF THE LOWER LIMB

The muscles of the abdomen and back are inserted into the anterior margin of the pelvic girdle, and the genito-ano-coccygeal musculature into the posterior margin. But there are not, as in the case of the arm, muscles of the axial region highly specialised for the sake of producing movements of the leg. The muscles of the lower limb are all intrinsic and arise during embryonic development from the blastema of the limb-bud.

As in the case of the intrinsic muscles of the arm, the muscles of the lower limb are divisible into two groups, a primary dorsal and a primary ventral. Owing to rotation during embryonic development the primary dorsal (abductor, extensor, and peroneal) muscles of the thigh and leg come to lie on the front and outer side; the primary ventral (adductor and flexor) muscles on the back and medial side of the limb. In the pelvic region the primary dorsal musculature extends over the front of the iliac blade to the lumbar region of the spinal column (ilio-psoas), and dorsally over the back of the iliac blade (gluteal group of muscles); the primary ventral musculature extends from the pubis and ischium to the great trochanter (obturator internus group). In the foot the primary dorsal musculature lies on the dorsum of the foot; the primary ventral in the sole.

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* According to R. Fick, the diaphragm plays a less important part in inspiration than is usually assumed for it.

In the arm one chief nerve for the dorsal musculature (the radial) and three for the ventral musculature (musculocutaneous, median, and ulnar) extend beyond the shoulder-girdle into the arm. Of the three chief nerves of the lower limb, one, the femoral (anterior crural), arises from the back of the lumbar plexus and supplies the definitively ventral (primarily dorsal) muscles of the thigh; another, the obturator, arises from the front of the plexus and supplies the adductor (primarily ventral) muscles, which have a definitive position on the medial side of the thigh; while a third, the sciatic, is composed of two parts, one, the tibial (internal popliteal), arising from the front of the sacral plexus and supplying the definitively dorsal (primarily ventral) muscles of the thigh and leg and the muscle of the sole of the foot; the other, the peroneal (external popliteal), arising from the back of the plexus and supplying the definitively lateral (primarily dorsal) muscles of the leg and the muscle of the dorsum of the foot. In the region of the hip-girdle, as in the region of the shoulder-girdle, there are special nerves arising from the back of the limb plexus for the dorsal muscles, and from the front of the plexus for the ventral muscles.

In addition to the ventro-dorsal division of the limb musculature the muscles may also be grouped according to the segments of the limb with which they are most closely associated—those of the hip, the thigh, the leg and foot. They will be taken up in the order named.

A. MUSCULATURE OF THE HIP

1. Dorsal Musculature of the Hip

The iliac blade divides these muscles into an **anterior group** (ilio-psoas), supplied by nerves from the lumbar plexus, and a **posterior group** (the gluteal muscles, piriformis, and tensor fasciæ latæ), supplied by nerves from the sacral plexus. In most of the limbed vertebrates these two groups of muscles are represented, but they present marked specific variations in the different forms. Primitively, the iliacus group lies on the proximal portion of the lateral surface of the ilium.

(*a*) Anterior Group

(Figs. 353, 358)

The fan-shaped **iliacus** muscle arises from the iliac fossa. The fusiform **psoas major** muscle arises from the sides of the last thoracic and of the lumbar vertebræ and extends along the medial margin of the iliacus muscle. The two muscles are inserted by a common tendon into the lesser trochanter of the femur. Together they constitute the **ilio-psoas** muscle. The small, flat, fusiform **psoas minor** lies on the medial surface of the psoas major and extends from the twelfth thoracic vertebra to the ilio-pectineal eminence. The ilio-psoas flexes the thigh at the hip and the pelvis on the trunk. The psoas minor aids in flexing the pelvis.

The ilio-psoas muscle arises in the human embryo from a blastema which at first surrounds the femoral nerve and later extends proximally over the ilium (iliacus) and towards the lumbar vertebræ (psoas). The iliacus is phylogenetically the more primitive. In the shoulder it is probably represented by the infraspinatus. The psoas minor is much better developed in many of the lower mammals than in man.

The **fasciæ** and the relations of these muscles are shown in figs. 345 and 354.

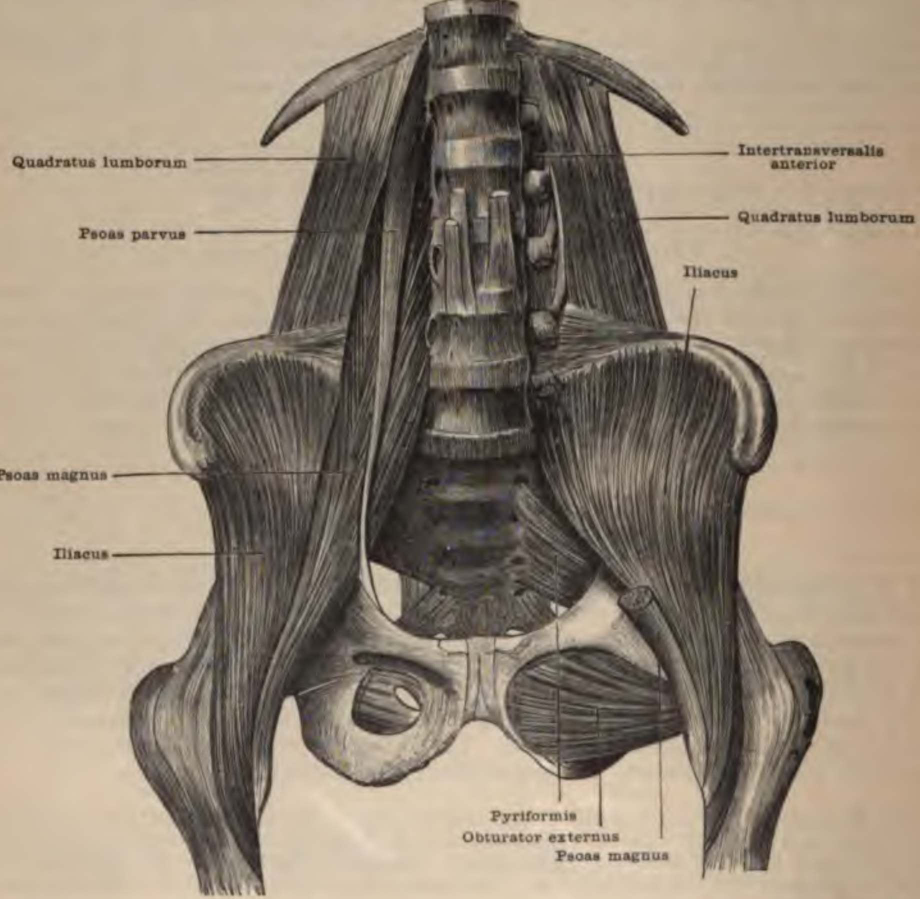
The iliac and psoas muscles are covered by a dense fascia which is but slightly adherent to the underlying muscles. This is best developed in the pelvic region, where it extends from the iliac crest and ilio-lumbar ligament to the iliac portion of the linea arcuata and is called the **iliac fascia.** Proximally it is continued over the psoas muscle as the **psoas fascia** and is attached medially to the sacrum and the lumbar region of the spinal column. Laterally it unites with the lumbar fascia and proximally it is strengthened to form the medial lumbo-costal arch (fig. 352). Distally the **pectineal fascia** extends over the ilio-psoas muscle to its femoral insertion. It is firmly united on each side of the muscle to the capsule of the hip-joint and to the femur. As it passes beneath the inguinal ligament it is united to this by tendinous processes. Beyond the ligament it is less dense than in the pelvic region.

MUSCLES

The psoas major (figs. 353, 358).—*Origin.*—(1) By a series of thick fasciculi from the intervertebral discs between the twelfth thoracic and the fifth lumbar vertebra, from the adjacent parts of the bodies of these vertebræ and from tendinous arches which bridge over the middle of the sides of the first four lumbar vertebræ; and (2) by a series of more slender fasciculi from the distal borders and ventral surfaces of the transverse processes of the lumbar vertebræ.

Structure and Insertion.—From these origins parallel fibre-bundles descend nearly vertically and give rise to a fusiform muscle which lies at the side of the vertebral bodies and extends along the border of the true pelvis towards its insertion. A tendon arises deep in the muscle near the last lumbar vertebra, and becomes free on its dorso-lateral surface slightly above the inguinal (Poupart's) ligament. On the medial side the attachment of fibre-bundles continues to the insertion of the muscle into the small trochanter. The iliacus muscle is attached to the lateral side of the tendon from near the ilio-psoas eminence distally.

Fig. 353.—Psoas, Iliacus, and Quadratus Lumborum.



Nerve-supply.—Delicate branches pass into the psoas muscle from the trunks which unite to form the femoral (anterior crural) nerve, i. e., from the fourth, third, second, and often the first lumbar nerves.

The iliacus (figs. 353, 358).—*Origin.*—(1) From the iliac crest, the ilio-lumbar ligament, and the greater part of the iliac fossa, the anterior sacro-iliac ligaments, and often from the sacrum, and (2) from the ventral border of the ilium between the two anterior spines.

Structure and Insertion.—From these areas of origin the fibre-bundles pass to be inserted—(1) in a penniform manner on the lateral surface of the tendon which emerges from the psoas above the inguinal (Poupart's) ligament, and (2) directly on the femur immediately distal to the small trochanter. The lateral portion of the muscle arises from the ventral border of the ilium and is adherent to the direct tendon of the rectus femoris and the capsule of the hip-joint. It is sometimes more or less isolated (*m. iliacus minor, ilio-capsulo-trochantericus*, etc.).

Nerve-supply.—Nerve branches, often united in a plexiform manner, arise from the femoral (anterior crural) nerve and pass across the surface of the iliacus muscle about midway between the crest of the ilium and the combined ilio-psoas tendon. Special nerve branches are usually likewise distributed from the main trunk of the femoral nerve to the fleshy portion of the muscle which extends over the acetabulum and the head of the femur.

Relations.—The psoas major lies lateral to the lumbar vertebræ and in front of the quadratus lumborum and intertransverse muscles. The psoas minor passes distally across its ventral surface. Both psoas muscles are crossed by the crura of the diaphragm. The kidney with its adipose capsule lies lateral to them opposite the first two lumbar vertebræ. For the rest, their fascia is covered ventro-laterally by retro-intestinal and retro-peritoneal tissue in which the vena cava inferior runs in front of them on the right side, the inferior mesenteric vein in front of them on the left side, and the ureter, the spermatic or ovarian, and the renal and colic vessels on each side. The external iliac artery lies medial to the psoas major in the pelvis, and beyond the inguinal (Poupart's) ligament the femoral artery lies ventral to it. The lumbar plexus arises between its origins from the vertebral bodies and discs and those from the transverse processes. The nerves springing from the lumbar plexus take courses subject to much individual variation through the muscle on the way to their destinations. Fasciculi of the muscle may thus be separated by the femoral (anterior crural) nerve or other branches of the lumbar plexus.

The iliacus muscle in the region of the pelvis is covered by retro-peritoneal fat. The psoas muscle crosses its medial margin and from between the two muscles the femoral nerve usually emerges to pass into the thigh above the iliacus. Beyond the inguinal ligament the iliacus lies in front of the capsule of the hip-joint and the straight tendon of the rectus femoris, and is crossed by the sartorius.

Action.—The ilio-psoas is a powerful flexor of the thigh at the hip and a weak internal rotator. It also serves to flex the lumbar region of the spine.

Variations.—The psoas muscle may be separated from the iliacus as far as the femoral insertion. The part of the psoas arising from the distal lumbar vertebræ may form a distinct muscle. Slips may pass from the psoas major to the psoas minor. A separate lamina of the iliacus muscle may be attached to the iliac fascia. From the anterior inferior iliac spine a small muscle slip may run to the intertrochanteric line or the ilio-femoral ligament. To this slip the term **iliacus minor** has been applied as well as to the larger fasciculus mentioned above.

The psoas minor (fig. 353).—*Origin.*—From the twelfth thoracic and first lumbar vertebræ and the intervening disc.

Structure and Insertion.—The fibre-bundles pass to be attached as far as the level of the fifth lumbar vertebra to a flat tendon which appears about the mid-lumbar region and is inserted into the ilio-pectineal eminence. It is intimately united to the iliac fascia.

Nerve-supply.—The branch to the psoas minor arises usually from the first and second lumbar nerves, often in company with the genito-femoral (genito-crural).

Action.—To flex the pelvis.

Relations.—It is closely applied to the ventral surface of the psoas major.

Variations.—The muscle is inconstant in development and is frequently absent. Gruber has found it absent on both sides in 183 out of 450 bodies, on one side in 69.

BURSÆ

B. iliopectinea.—A large bursa between the ilio-psoas muscle, the ilio-pectineal eminence, and the capsule of the hip-joint. **B. iliaca subtendinea.**—A small bursa between the tendon of insertion of the ilio-psoas and the lesser trochanter.

(*b*) POSTERIOR GROUP

(Figs. 348, 354–360)

The muscles of this group arise from the ilium and sacrum, cover the dorso-lateral surface of the hip, and are inserted into the great trochanter and shaft of the femur and into the ilio-tibial band. They lie in three planes. In the **first layer** (fig. 348) are the flat, quadrilateral **tensor fasciæ latæ,** which arises from the front of the crest of the ilium and is inserted into the ilio-tibial band, and the thick, rhomboid **gluteus maximus,** which arises from the dorsal portion of the iliac ala, the lumbo-dorsal fascia, the sacrum and coccyx, and the sacro-tuberous (great sacro-sciatic) ligament, and is inserted in part into the ilio-tibial band and in part into the back of the upper part of the shaft of the femur. The **ilio-tibial** band is a flat tendon which descends, closely fused with the fascia lata, to the lateral side of the upper extremity of the tibia. In the **second layer** (fig. 355) are the flat, thick, triangular **gluteus medius** and the 'pear-shaped' **piriformis.** The former arises from the upper and back part of the outer surface of the ala of the ilium, the latter from the ventral surface of the sacrum and the posterior border of the great sciatic notch. Both are inserted into the top of the great trochanter. The **third layer** (fig. 356) is composed of the triangular **gluteus minimus,** which arises from the inferior ventral portion of the outer surface of the ala of the ilium, and is inserted into the front of the great trochanter of the femur.

The muscles of this group extend, abduct, and rotate the thigh at the hip. The gluteus maximus is the extensor. All the muscles serve to abduct, the piriformis act-

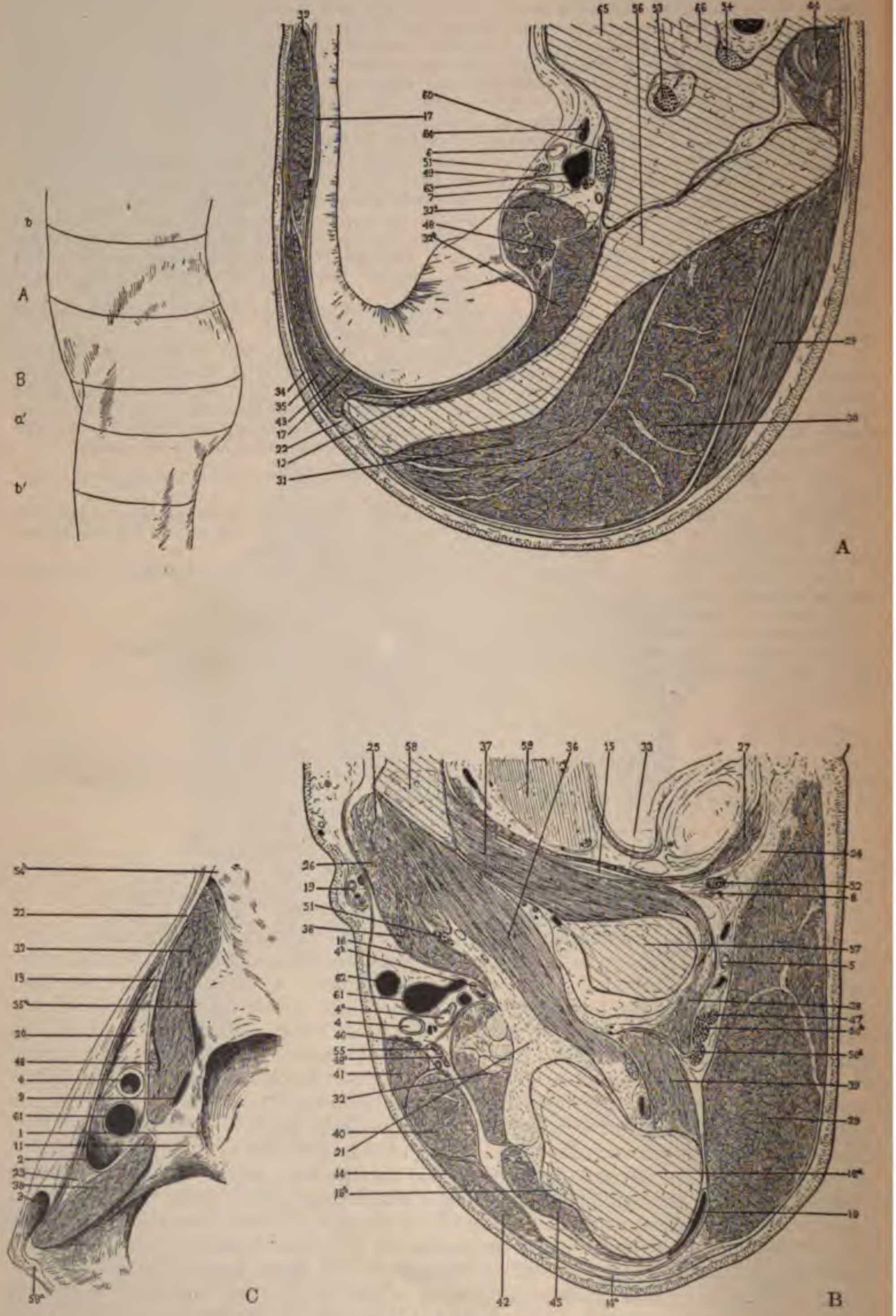

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FIG. 354.

ing thus when the hip is flexed. The gluteus maximus and posterior part of the gluteus medius and the piriformis act as external, the anterior part of the gluteus medius, the gluteus minimus, and the tensor fasciæ latæ as internal, rotators. The gluteus maximus and the tensor fasciæ latæ through the ilio-tibial band serve to keep the extended knee-joint firm.

The gluteus medius, gluteus minimus, and piriformis form a group of muscles which in the embryo have a common origin and are more or less fused in the adult. The gluteus maximus arises as two distinct, though associated, portions, and the tensor fasciæ latæ as another distinct portion. The two muscles, however, are probably to be considered as parts of a primitive caudo-pelvo-tibial musculature, while the gluteus medius group is represented in the lower forms by an ilio-femoral musculature. The former group is often closely associated with the extensor muscles of the thigh in the lower forms (frog), and in some of the lower mammals extends its insertion to the plantar fascia (ornithorhynchus). In the arm this group is perhaps represented by the deltoid, the latissimus dorsi, and the teres major, while the gluteus medius group is represented by the subscapularis.

The **tela subcutanea** of the gluteal region is very thick, contains much fat, and is often divisible into two layers, of which the deeper is closely adherent to the fascia lata and through this to the gluteus maximus. Over the great trochanter a subcutaneous bursa is usually found (**bursa trochanterica subcutanea**).

Muscle fascia.—The muscles of the hip and thigh are enclosed in a dense fascia, the **fascia lata** (figs. 348, 354). This arises from the tuber ischii, the sacro-tuberous (great sacro-sciatic) ligament, the back of the sacrum and the coccyx, the crest of the ilium, the inguinal (Poupart's) ligament, and the pubic and ischial rami, and extends to the tibia and the fascia covering the muscles of the leg. It is composed mainly of bundles of fibres running transversely to the long axis of the limb. In the region of the gluteal groove it is strengthened by a transverse fibrous band which arises from the tuberosity of the ischium and arches upwards over the lower border of the gluteus maximus muscle.

In the region of the hip the fascia lata invests both surfaces of the tensor fasciæ latæ and the gluteus maximus, and is closely bound to these muscles through intramuscular septa. Between these two muscles the fascia covers the fascia of the gluteus medius, to which it is adherent near the iliac crest, but from which it is separated by loose tissue more distally. Anteriorly the fascia is fused with the ilio-pectineal fascia and the inguinal (Poupart's) ligament.

More distally the tendons of the tensor fasciæ latæ and of the superficial portion of the gluteus maximus become incorporated with the deep surface of the fascia lata and give rise to the **ilio-tibial band.**

The gluteus medius and minimus muscles are invested by adherent fascial sheets which, ventrally between the two muscles, may be combined into an intermuscular

FIG. 354, A and B.—TRANSVERSE SECTIONS THROUGH THE LEFT SIDE OF THE PELVIS IN THE REGIONS INDICATED IN THE DIAGRAM.

C. Section through the muscles of the left inguinal region parallel to the inguinal (Poupart's) ligament (after Spalteholz). *b* in the diagram indicates section B, fig. 345 (p. 410); *a′* and *b′* indicate sections A and B, fig. 357 (p. 436).

1. Acetabulum. 2. Femoral ring. 3. Subcutaneous inguinal (ext. abdominal) ring. 4. Femoral artery—*a*, deep femoral artery; *b*, medial circumflex artery. 5. Inferior gluteal (sciatic) artery. 6. Internal iliac (hypogastric) artery. 7. External iliac artery. 8. Pudendal (pudic) artery. 9. Bursa ilio-pectinea. 10. Bursa trochanterica m. glutæi maximi. 11. Eminentia ilio-pectinea. 12. Iliac fascia. 13. Ilio-pectineal fascia. 14. Fascia lata—*a*, ilio-tibial band. 15. Obturator fascia. 16. Pectineal fascia. 17. Transversalis fascia. 18. Femur—*a*, great trochanter; *b*, small trochanter. 19. Spermatic cord. 20. Lacuna vasorum. 21. Ilio-femoral ligament. 22. Inguinal (Poupart's) ligament. 23. Lacunar (Gimbernat's) ligament. 24. Sacro-tuberous (great sacro-sciatic) ligament. 25. Adductor brevis. 26. Adductor longus. 27. Coccygeus. 28. Gemellus inferior. 29. Gluteus maximus. 30. Gluteus medius. 31. Gluteus minimus. 32. Ilio-psoas—*a*, iliacus; *b*, psoas. 33. Levator ani. 34. Obliquus abdominis externus, aponeurosis. 35. Obliquus abdominis internus. 36. Obturator externus. 37. Obturator internus. 38. Pectineus. 39. Rectus abdominis. 40. Rectus femoris. 41. Sartorius. 42. Tensor fasciæ latæ. 43. Transversus abdominis. 44. Transverso-spinales (multifidus). 45. Vastus lateralis. 46. Anterior middle cutaneous nerve. 47. Posterior femoral cutaneous (small sciatic) nerve. 48. Femoral (anterior crural) nerve—*a*, branches to quadriceps femoris. 49. Superior gluteal nerve. 50. Sciatic nerve—a, peroneal (external); b, tibial (internal popliteal). 51. Obturator nerve. 52. Pudendal (pudic) nerve. 53. I sacral nerve. 54. II sacral nerve. 55. Saphenous (long saphenous) nerve. 56. Ilium—a, anterior superior spine; b, anterior inferior spine. 57. Ischium. 58. Pubis—a, tubercle (spine). 59. Prostate gland. 60. Lumbo-sacral trunk. 61. Femoral vein. 62. Great saphenous vein. 63. External iliac vein. 64. Hypogastric (internal iliac) vein. 65. I sacral vertebra. 66. II sacral vertebra.

septum or be so slightly developed that the muscles are fused. The fascial sheet covering the gluteus medius towards the iliac crest is fused with the deep surface of the fascia lata. This fusion results in the formation of septa between the gluteus medius and the gluteus maximus and tensor fasciæ latæ.

The piriformis in the pelvic cavity is covered on the anterior surface by a special slightly developed fascia. This fascia also covers the pelvic surface of the sacral plexus. Outside the pelvis the piriformis is covered by an adherent membrane which usually is separated by loose tissue from the surrounding structures.

MUSCLES

I. FIRST LAYER

The tensor fasciæ latæ (figs. 348, 358).—*Origin.*—(1) By a tendinous band from the external lip of the iliac crest, and the upper part of the notch between the anterior superior and anterior inferior spines of the ilium, and (2) from the septum between it and the gluteus medius.

Structure and Insertion.—The nearly parallel fibre-bundles pass distally and laterally and are united to tendon fasciculi which become incorporated with the ilio-tibial band (tractus ilio-tibialis) about one-third of the way down the thigh.

Nerve-supply.—The superior gluteal nerve sends a branch through the ventral margin of the gluteus minimus to terminate in the middle third of the deep surface of the tensor fasciæ latæ near its dorsal border.

Action.—To rotate medially, flex, and abduct the thigh, and to make tense the fascia lata.

Relations.—It lies over the gluteus medius, the proximal part of the rectus femoris, and the vastus lateralis.

Variations.—It may be divided into two parts, one arising from the anterior superior spine, the other from the iliac crest. Accessory slips may arise from the inguinal ligament, the crest of the ilium, or the fascia over the lower part of the abdominal wall. Union of the muscle with the gluteus maximus has been observed, thus making a muscle much resembling the deltoid of the shoulder. By some the fascia lata between the tensor and the gluteus maximus is considered an atrophied part of a deltoid of the hip.

The gluteus maximus (figs. 348, 360).—*Origin.*—(1) From the dorsal fifth of the outer lip of the iliac crest, the outer surface of the ilium dorsal to the posterior gluteal line, the lumbodorsal fascia between the posterior superior spine of the ilium, and the side of the sacrum, and (2) from the lateral portions of the fourth and fifth sacral and the coccygeal vertebræ and from the back of the sacro-tuberous (great sacro-sciatic) ligament.

Insertion.—Into (1) the ilio-tibial band; (2) the gluteal tuberosity of the femur and the adjacent part of the tendinous origin of the vastus lateralis (fig. 354).

Structure.—The large fibre-bundles of which the muscle is composed take a somewhat parallel course from origin to insertion. From the areas of origin and the enveloping fascia fibrous bands extend into the muscle. The belly is divisible into two portions, a superficial and a deep. The division may be much more clearly recognised in the embryo than in the adult. The superficial portion is the larger, and includes all of that part of the muscle which springs from the ilium and the more superficial portion of that arising from the sacrum and the upper part of the coccyx. The deep portion includes that part of the muscle attached to the side of the sacrum and the coccyx, and to the sacro-tuberous ligament. The superficial portion and some of the fibre-bundles of the deep portion terminate in the ilio-tibial band along a line extending from the great trochanter to the end of the upper third of the femur. The deep portion is inserted chiefly by a flat tendon into the gluteal tuberosity, and also directly into the adjacent portion of the origin of the vastus lateralis.

Nerve-supply.—Two branches, arising from the sacral plexus either separately or in a common trunk, are usually given to the muscle. One of these curves anteriorly across the deep surface of the proximal superficial portion of the muscle in the middle third between the tendons of origin and insertion, the other descends to enter the middle third of the distal deep portion of the muscle.

Action.—It is the most powerful extensor of the thigh. It also serves slightly to rotate the leg outwards and to make tense the fascia lata, and through the ilio-tibial band to keep the extended knee-joint steady. It is a weak abductor. By some the lower part of the muscle is said to act as an adductor. It is brought powerfully into play in climbing and in walking up hill.

Relations.—It is covered by the fatty superficial tissue of the buttock. It extends over the posterior portion of the ilium, the lateral surface of the sacrum and coccyx, the sacro-tuberous ligament, and the great trochanter. It covers the tuber of the ischium in the standing but not in the sitting position. Immediately beneath the muscle lie portions of the gluteus medius, piriformis, obturator internus, gemelli, quadratus femoris, obturator externus, and hamstring muscles, and of the gluteal vessels and nerves and the sciatic nerve.

Variations.—Few anomalies are recorded. The deep distal portion of the muscle may be more isolated than normal in the adult. A special coccygeo-femoral muscle may run from the coccyx to the linea aspera, or from the sacro-tuberous ligament to the fascia of the leg. A special fasciculus, the **ischio-femoralis**, may arise from the tuberosity of the ischium and become inserted into the lower border of the muscle near the great trochanter. The sacral, ischial, or coccygeal origin may be lacking, or the origin of the muscle may be from the sacrum only.

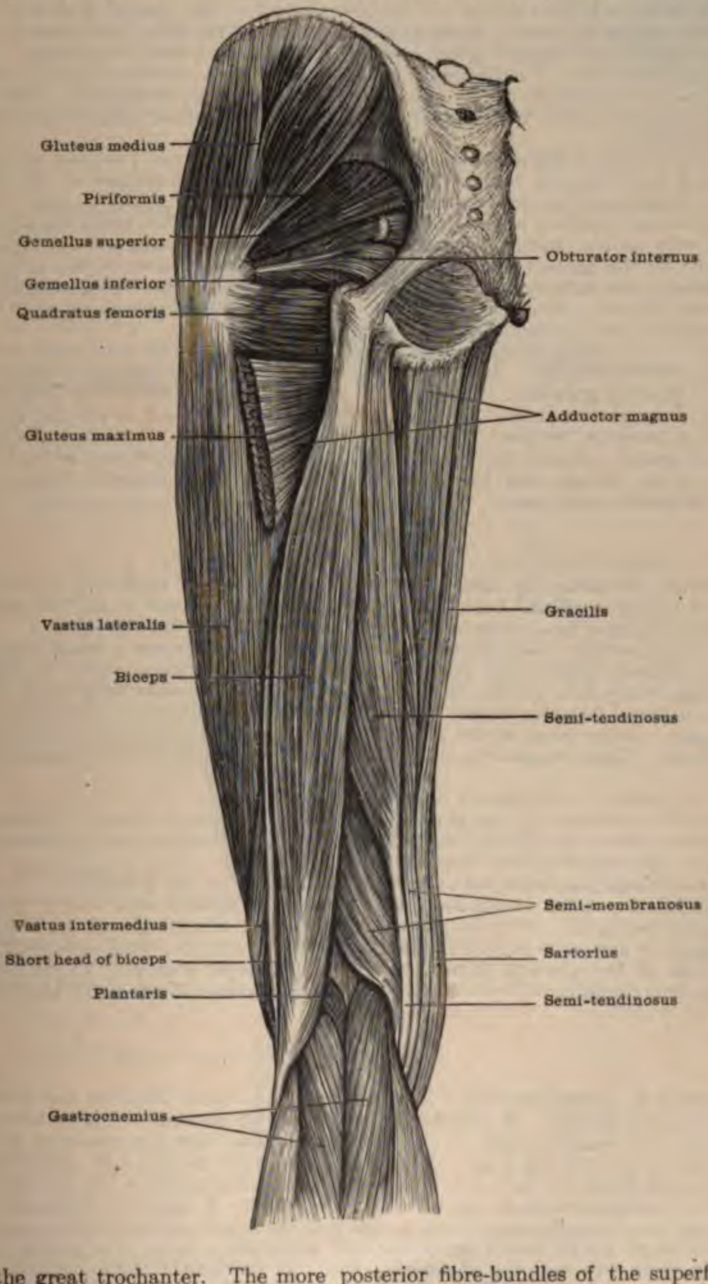
II. Second Layer

The muscles of this layer are the gluteus medius and the piriformis.

The gluteus medius (fig. 355).—*Origin.*—From (1) the ventral three-fourths of the iliac , and the outer surface of the ilium between the anterior and posterior gluteal lines and (2) investing fascia.

Structure and Insertion.—The fibre-bundles converge upon both surfaces of a broad tendon ly to its insertion on an oblong impression on the postero-superior angle and the external

Fig. 355.—The External Rotators and the Hamstring Muscles.


Gluteus medius
Piriformis
Gemellus superior
Gemellus inferior
Quadratus femoris
Gluteus maximus
Vastus lateralis
Biceps
Vastus intermedius
Short head of biceps
Plantaris
Gastrocnemius
Obturator internus
Adductor magnus
Gracilis
Semi-tendinosus
Semi-membranosus
Sartorius
Semi-tendinosus

e of the great trochanter. The more posterior fibre-bundles of the superficial stratum e ventral portion of the muscle cross obliquely those of the deeper dorsal portion near endon of insertion. From the tendon an aponeurotic extension is usually continued into ndon of the vastus lateralis.

erve-supply.—From the superior gluteal nerve a branch passes to the dorsal portion of the e and one or more twigs of the branch to the tensor fasciæ latæ enter the ventral portion of the muscle. The branches enter the middle third of the muscle between its tendons of origin and insertion. The nerve-fibres arise usually from the fourth and fifth lumbar and first sacral nerves. The branch to the dorsal portion of the muscle has a more distal spinal origin than those to the ventral portion.

Action.—To abduct the thigh. The anterior portion of the muscle is an internal, the posterior an external, rotator. When the muscle acts as a whole, it is an internal rotator.

Relations.—Upon the muscle lie the tensor fasciæ latæ and gluteus maximus muscles and the fascia lata; beneath it lie the gluteus minimus muscle, the superior gluteal nerve and vessels, and the great trochanter.

Variations.—It may be divided into two distinct portions, or it may be fused with the piriformis or the gluteus minimus or both. A special fasciculus may extend to the superior portion of the great trochanter.

The piriformis.—*Origin.*—From (1) the lateral part of the ventral surface of the second, third, and fourth sacral vertebræ; (2) the posterior border of the great sciatic notch; and (3) the deep surface of the sacro-tuberous (great sacro-sciatic) ligament near the sacrum.

Structure and Insertion.—The fibre-bundles converge upon a tendon which is inserted upon the anterior and inner portion of the upper border of the great trochanter. The insertion of fibre-bundles continues nearly to the great trochanter. An accessory slip of insertion may pass to the gluteus minimus.

Nerve-supply.—From a nerve which arises either directly from the first or second sacral nerve or from a loop between them. The nerve enters the deep surface of the muscle in its middle third. There may be two or more nerves.

Action.—Outward rotation of the thigh. It also causes abduction when the hip is flexed.

Relations.—Its ventral surface faces the sacral plexus, the rectum, and the hip-joint. It is covered dorsally by the gluteus maximus. It lies between the gluteus medius and the superior gemellus. Between the piriformis and the superior gemellus the sciatic nerve usually passes into the thigh. The superior gluteal nerve and vessels pass dorsally above its superior margin; the inferior nerve and vessels beneath its inferior margin.

Variations.—It is rarely absent. The origin may extend to the first sacral or to the fifth sacral vertebra and the coccyx. It may be fused with the gluteus medius or minimus or more rarely with the superior gemellus. Its tendon of insertion may be fused with that of the gluteus medius or the obturator internus. In about 20 per cent. of bodies it is divided partly or completely into two portions, between which the sciatic nerve or its peroneal (external popliteal) division usually passes. Rarely the tibial instead of the peroneal portion may pass between the two fasciculi, or the muscle may be divided into three or more fasciculi, between which the branches of the sciatic nerve pass.

III. THIRD LAYER

The gluteus minimus (fig. 356).—*Origin.*—From the outer surface of the ilium between the anterior and inferior gluteal lines; (2) from the septum between it and the gluteus medius near the anterior superior iliac spine; and (3) from the capsule of the hip-joint.

Structure and Insertion.—The fibre-bundles converge upon a tendon which appears on the middle of the ventral border and gradually spreads over the lateral surface. The muscle is thickest in front, where it is usually bound by an intermuscular septum to the gluteus medius. The tendon is inserted into the ventral surface of the great trochanter of the femur.

Nerve-supply.—From twigs of the branch of the superior gluteal nerve which goes to the tensor fasciæ latæ. These twigs enter the middle third of the muscle as the tensor branch passes across it.

Action.—To abduct the thigh and rotate it inwards.

Relations.—It is covered by the gluteus medius and piriformis muscles. Beneath it lie the inferior part of the iliac ala, the hip-joint (to the capsular ligament of which it is bound), and the direct tendon of the rectus femoris muscle.

Variations.—It may be fused with the gluteus medius or the piriformis. It may send a slip to the fascia lata or the vastus lateralis. It may be divided into two distinct divisions, an anterior and a posterior. Very frequently from the anterior margin of the muscle a special fasciculus is more or less isolated (the **scansorius,** invertor femoris, small anterior gluteal, etc.). The **accessorius of the gluteus minimus** is a small muscle fasciculus which may lie under cover of the gluteus minimus and extend to be inserted into the capsule of the hip-joint.

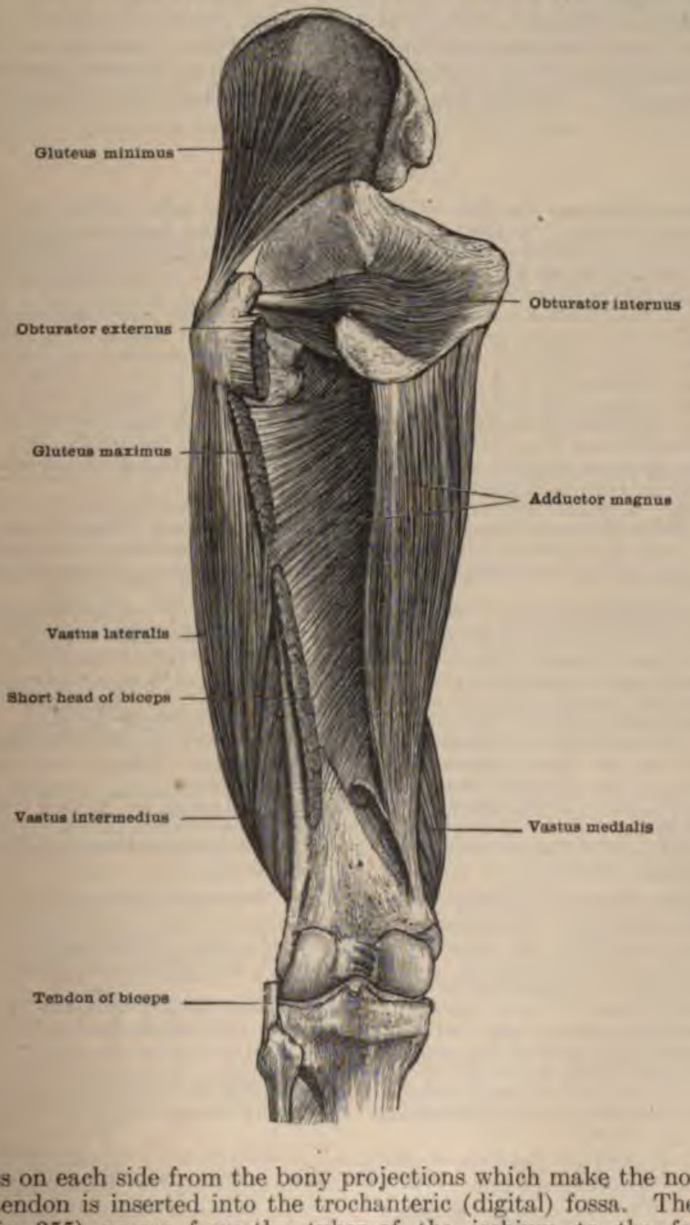
BURSÆ

B. ischiadica m. glutei maximi.—A small inconstant bursa between the tuber ischii and the gluteus maximus muscle. **B. trochanterica m. glutei maximi.**—A large bursa constantly present between the fascial tendon of the gluteus maximus and the posterior lateral surface of the great trochanter and the origin of the vastus lateralis muscle. **B. gluteofemorales.**—Two or three small bursæ on each side of the tendon of attachment of the gluteus maximus to the femur. **B. trochanterica m. glutei medii anterior.**—A small bursa constantly present between the tendon of the gluteus medius muscle and the lateral surface of the great trochanter. **B. trochanterica m. glutei medii posterior.**—A small bursa frequently present between the tendons of the piriformis and the gluteus medius. **B. trochanterica m. glutei minimi.**—A fairly large bursa generally present between the margin of the great trochanter and the tendon of this muscle. **B. m. piriformis.**—A small bursa frequently present between the tendons of the piriformis and superior gemellus muscles and the femur.

2. VENTRAL MUSCULATURE OF THE HIP

The muscles belonging to this group (the obturator internus, the two gemelli, and the quadratus femoris) extend from the pubis and ischium across the back of the hip-joint to the great trochanter and the neighbouring shaft of the femur. They are powerful external rotators of the thigh. The **obturator internus** (fig. 356), a large, flat, triangular muscle, arises on the inner surface of the true pelvis. At the lesser sciatic notch its tendon is joined by the two **gemelli** (fig. 355), one of which arises on each side from the bony projections which make the notch, and the combined tendon is inserted into the trochanteric (digital) fossa. The **quadratus femoris** (fig. 355) passes from the tuber of the ischium to the femur behind and below the great trochanter. A fifth muscle, attached to the greater trochanter and associated with this group, the **obturator externus,** is differentiated near the adductor muscles of the thigh and is supplied by a branch from the obturator nerve, and will, therefore, be considered in connection with the adductor muscles.

FIG. 356.—THE DEEP MUSCLES OF THE BACK OF THE THIGH.


Gluteus minimus
Obturator internus
Obturator externus
Gluteus maximus
Adductor magnus
Vastus lateralis
Short head of biceps
Vastus intermedius
Vastus medialis
Tendon of biceps

These muscles seem to have no certain representatives in the arm, where the shoulder-joint is entirely ensheathed by the dorsal musculature. It is possible that the pectoral group has a corresponding embryonic origin. The group is represented, with marked variations, in the legs of amphibia and all higher vertebrates.

Within the pelvis the obturator internus lies on the obturator membrane. It is covered by the **obturator fascia,** which is attached to the body of the pubis, to the iliac portion of the arcuate line, to the ventral margin of the great sciatic notch, to the ischial spine, to the sacro-tuberous (great sacro-sciatic) ligament, and with the falciform process of that ligament, to the ischial and pubic rami. Near the upper part of the obturator foramen the fascia instead of being attached to bone is reflected over the muscle and attached to the obturator membrane. It here helps to bound the canal for the obturator vessels and nerve. The upper part of the fascia lies beneath the pelvic peritoneum and the levator ani. The lower part forms the outer boundary of the ischio-rectal fossa. The fascia is continued as a thin, adherent membrane over the obturator internus and the gemellus muscles to their attachment. The quadratus femoris is invested by a thin adherent fascial sheet.

MUSCLES

The obturator internus (fig. 356).—*Origin.*—From (1) the pelvic surface of the pubic rami near the obturator foramen; (2) the pelvic surface of the ischium between the foramen and the great sciatic notch; (3) the deep surface of the obturator internus fascia; (4) the fibrous arch which bounds the canal for the obturator vessels and nerve; and (5) the pelvic surface of the obturator membrane except in the lower part.

Structure and Insertion.—From this extensive area of origin the fibre-bundles converge towards the lesser sciatic notch and become applied to the broad tendon of insertion. At the notch the muscle curves laterally and extends outwards and upwards to its insertion into the fore part of the trochanteric fossa of the femur. The tendon is formed of five or six bands which begin high in the muscle and converge into a common tendon situated on the deep surface of the muscle as the latter curves about the ischium. The tendon bands at first throw the tendon into folds which run in ridges in the fibro-cartilage which lines the notch. The attachment of fibre-bundles continues upon the dorsal surface of the tendon to half way between the lesser sciatic notch and the great trochanter.

Nerve-supply.—A special nerve to the obturator internus arises from the front of the sacral plexus, usually from the lumbo-sacral cord and the first and second sacral nerves. This nerve passes lateral to the sacro-spinous (lesser sciatic) ligament, then re-enters the pelvis through the lesser sciatic notch and sends out branches of distribution on the pelvic surface of the obturator internus.

Action.—This muscle with its two companions, the gemelli, is a powerful outward rotator of the thigh. It also acts as an abductor when the thigh is bent at a right angle.

Relations.—The chief pelvic relations have been described in connection with the obturator fascia which completely covers the medial surface of the muscle. The muscle passes out between the two sacro-ischial (sacro-sciatic) ligaments. Outside the pelvis the gemellus muscles run on each side of the tendon, which is here closely applied to the capsule of the joint. Dorsal to it lie the gluteus maximus, the sacro-tuberous (great sacro-sciatic) ligament, the inferior gluteal (sciatic) vessels, and the sciatic and posterior cutaneous nerves. The nerve of the quadratus femoris runs beneath the obturator internus and gemellus muscles.

Variations.—It varies in the extent of its insertions. It may be divided into two parts, a pubic and an ischial. Fasciculi may be sent to the postero-inferior part of the ilio-pectineal eminence, the tendon of the psoas minor, the tuber ischii, the sacro-tuberous (great sacro-sciatic) ligament, the ischial spine, etc.

The gemellus superior (fig. 355).—*Origin.*—From the outer surface of the ischial spine and the neighbouring edge of the lesser sciatic notch.

Structure and Insertion.—The fibre-bundles encircle the upper border and ventral aspect of the tendon of the obturator internus. They are inserted into the upper border of this tendon, and sometimes also into the trochanteric fossa.

Nerve-supply.—From a small nerve which arises either directly from the plexus or as a branch of the nerve to the obturator internus or of that to the quadratus femoris. This nerve usually enters the deep surface of the muscle near the junction of its ischial and middle thirds.

Action.—It is essentially a part of the obturator internus.

Relations.—It lies between the piriformis and the tendon of the obturator internus. Proximally it adjoins its fellow beneath this tendon; distally, the two gemelli enclose the tendon in a musculo-tendinous sheath.

Variations.—It may be wanting or may have a more extensive origin than usual. It may be joined to the piriformis or to the gluteus minimus or be joined more closely than usual to the obturator tendon.

The gemellus inferior.—*Origin.*—From the upper part of the inner border of the tuberosity of the ischium, the sacro-tuberous (great sacro-sciatic) ligament and from the neighbouring edge of the lesser sciatic notch.

Structure and Insertion.—The fibre-bundles converge upon the inferior border of the tendon of the obturator internus, and are inserted by tendon-fibres into this or into the great trochanter below the obturator internus tendon.

Nerve-supply.—From a branch of the nerve to the quadratus femoris. This branch enters the deep surface of the muscle near the junction of the ischial with the middle third.

Action.—It is essentially a part of the obturator internus.

Relations.—It lies between the quadratus femoris and the tendon of the obturator internus.

Variations.—It is rarely absent. It may be joined to the quadratus femoris. It is frequently closely bound up with the obturator internus. It may be doubled.

The quadratus femoris (fig. 355).—*Origin.*—From the upper part of the outer border of the tuber of the ischium.

Structure and Insertion.—The fibre-bundles take a nearly parallel course and are inserted into the vertical ridge which terminates above on the inferior dorsal angle of the great trochanter.

Nerve-supply.—From a nerve which arises usually from the lumbo-sacral cord and the first sacral nerve and passes under the gemelli and the tendon of the obturator internus. The nerve enters the deep surface of the muscle near the junction of the ischial and middle thirds.

Action.—It is a powerful external rotator and a weak adductor of the thigh.

Relations.—It is covered by the gluteus maximus. Between this muscle and the quadratus femoris runs the sciatic nerve. The obturator externus muscle lies in front. The inferior gemellus extends along its superior border. The adductor minimus adjoins it distally.

Variations.—It is absent in from 1 to 2 per cent. of instances. (Schwalbe and Pfitzner.) It may be double near its femoral insertion. It may be fused with the inferior gemellus or the adductor magnus. It may send a fasciculus to the semimembranosus.

BURSÆ

B. m. obturatoris interni.—A fairly large bursa constantly present between the tendon of the obturator internus muscle and the lesser sciatic notch. It may extend on each side beneath the gemellus muscles. **B. m. quadrati femoris.**—A small bursa frequently found between this muscle and the small trochanter.

B. MUSCULATURE OF THE THIGH

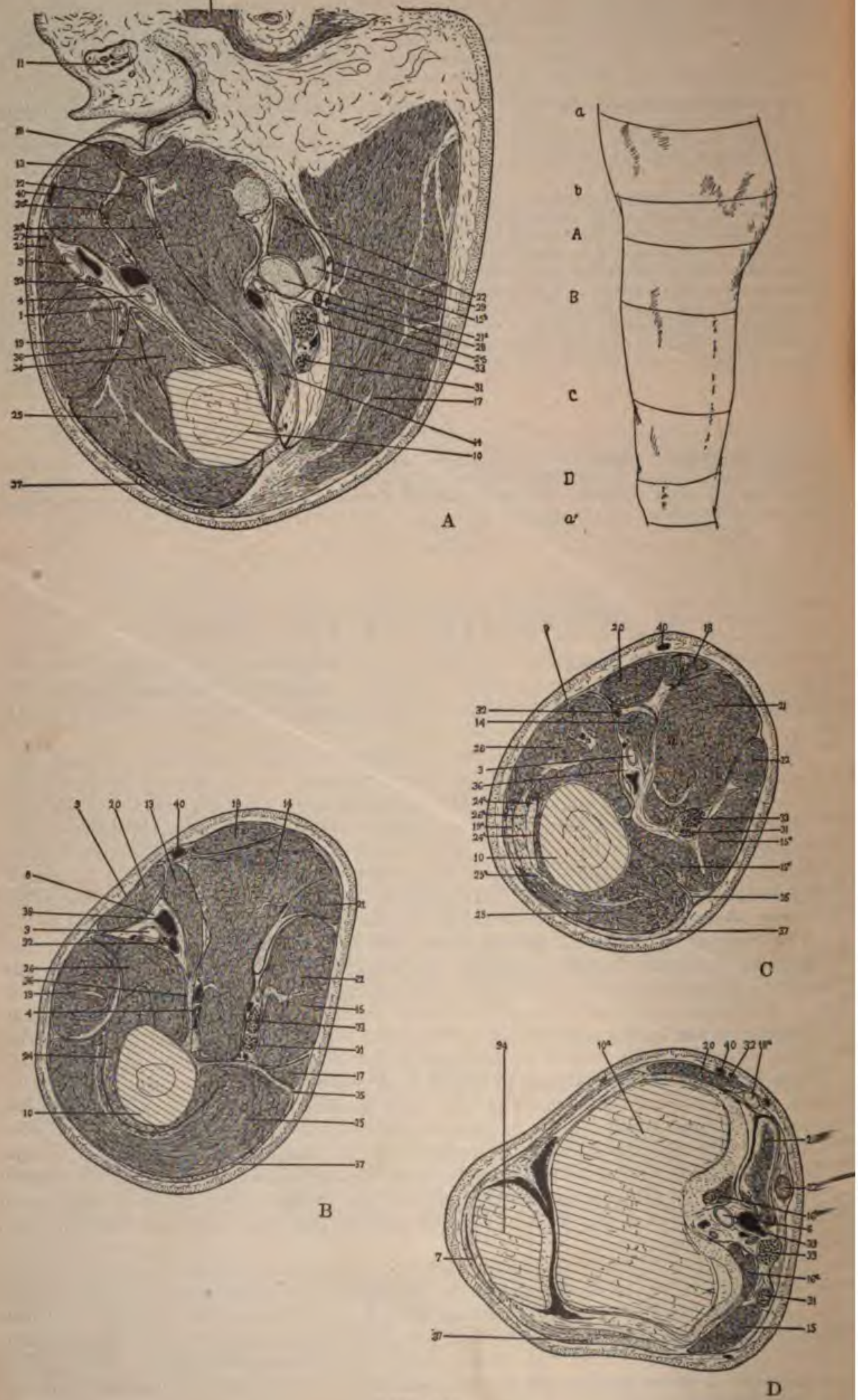
In the thigh three groups of muscles may be recognized:—an anterior, extensor group, innervated by the femoral nerve; a medial, adductor group, innervated by the obturator nerve; and a posterior, flexor or hamstring group, innervated by the sciatic nerve.

The **anterior group** (figs. 358, 359) is composed of the quadriceps femoris and the sartorius muscles. The **quadriceps** (rectus femoris, vastus lateralis, intermedius, and medialis) arises from the ilium and from the greater part of the shaft of the femur, and is inserted into the tibia by a strong tendon which passes over the front of the knee-joint and contains the patella. The muscle forms a semiconical mass, pointed hipwards. Posteriorly the shaft of the femur is embedded in this mass. The slender **sartorius** passes along the medial margin of the quadriceps from the ilium to the knee, and then sends a tendon around this joint to the tibia.

The **medial** or **adductor group** (figs. 356, 358, 359) consists of the **gracilis, pectineus, adductor longus, brevis,** and **magnus,** and the **obturator externus** muscles. These constitute a triangular mass of musculature which extends from the pubis and ischium to the back of the femur along a line extending from the great trochanter to the medial epicondyle. The most superficial muscle of the group, the gracilis, extends to the ventro-medial aspect of the upper part of the tibia.

The **posterior** or **hamstring group** (figs. 355, 360) constitutes a mass of muscles which arises from the tuber of the ischium and descends along the back of the leg between the extensor and adductor groups. Above the knee it bifurcates into two divisions. The *medial division,* composed of the **semimembranosus** and **semitendinosus,** gives rise to tendons inserted into the medial side of the upper extremity of the tibia. The *lateral division,* composed of the **biceps,** of which the second head arises from the back of the shaft of the femur, gives rise to a tendon inserted into the head of the fibula.

In the proximal part of the thigh the anterior group of muscles is separated from the medial group by the ilio-psoas muscle (fig. 358) and by the femoral blood-vessels and nerve, and from the posterior group by the gluteus maximus (fig. 360). More distally it is separated from the medial group by the medial intermuscular septum and from the posterior by the lateral intermuscular septum (see p. 438). The medial and posterior groups are closely associated. The adductor magnus belongs ontogenetically to both.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D

Fig. 357.

The three groups of muscles, with numerous modifications, are represented in the thighs of amphibia and all higher vertebrates. In the human arm they are likewise represented, the adductor group in a much reduced form by the coraco-brachialis. The quadriceps is represented by the triceps in the arm, the long head of the triceps corresponding with the rectus femoris. The hamstring muscles are represented by the biceps and the brachialis.

The **fasciæ** and the relations of the musculature of the thigh may be followed in the cross-sections figs. 354, 357, 361.

The **tela subcutanea** of the thigh varies considerably in thickness in different regions, but is well developed throughout and contains a considerable amount of fat. Over the front of the thigh, especially in the upper medial region, one or more deeper membranous layers may usually be separated from the superficial adipose layer. Between the former and the latter are situated the inguinal lymphatic nodes and the saphenous vein. The deepest layer near the inguinal (Poupart's) ligament is fused with the fascia lata (see below). Medially it is attached to the pubic arch. Thus fluids beneath the tela subcutanea of the abdomen and perineum do not readily pass into the region of the thigh.

Over the lower half of the patella a subcutaneous bursa (**b. præpatellaris subcutanea**) is found. Another is usually found over the upper end of the patellar ligament (**b. infrapatellaris subcutanea**).

The muscles of the thigh are enclosed in a dense fascial sheet, the **fascia lata** (figs. 348, 357). The gluteal portion of this and the ilio-tibial band have already been described (p. 427). The ventral portion of the fascia, composed chiefly of transverse fibres, is a dense, fibrous membrane. Above it is attached to the inguinal ligament from the anterior superior spine to the pubic tubercle. Below it extends over the knee, where it is united to the capsule of the joint and is strengthened by expansions from the vastus lateralis and medialis. Between the front of the patella and the fascia is a bursa (**b. præpatellaris subfascialis**). Above the knee the fascia is strengthened by an *arciform process* which extends obliquely distally across the fascia from the ilio-tibial band to the capsule of the knee. This gives rise to a fold in the skin when the leg is extended and the muscles are not tense. Over the medial and posterior regions of the thigh the fascia is less dense. It extends from the body and inferior ramus of the pubis, the inferior ramus and tuber of the ischium, and the sacro-tuberous ligament into the fascia of the back of the leg. Above the popliteal space it is strengthened by a transverse band of fibres. Near the knee the tendons of the quadriceps, sartorius, gracilis, and semitendinosus become bound to the fascia by membranous laminæ.

The relations of the fascia lata to the inguinal ligament and the iliac fascia are somewhat complex. The fascia of the ilio-psoas muscle extends over the muscle to its femoral insertion. Above the inguinal ligament this fascia is called the **fascia iliaca;** below the ligament, the **fascia ilio-pectinea.** This fascia is firmly united to the lateral extremity of the inguinal ligament. The pectineus muscle is likewise invested with a fascial membrane which extends over the muscle from the pubis to the femur and is fused laterally with that of the ilio-psoas. This combined fascia is firmly bound between the two muscles to the ilio-pectineal eminence. The ilio-pectineal fascia divides the space beneath the inguinal ligament into a lateral **lacuna musculorum,** which contains the ilio-psoas muscle and the femoral (anterior crural) nerve, and a

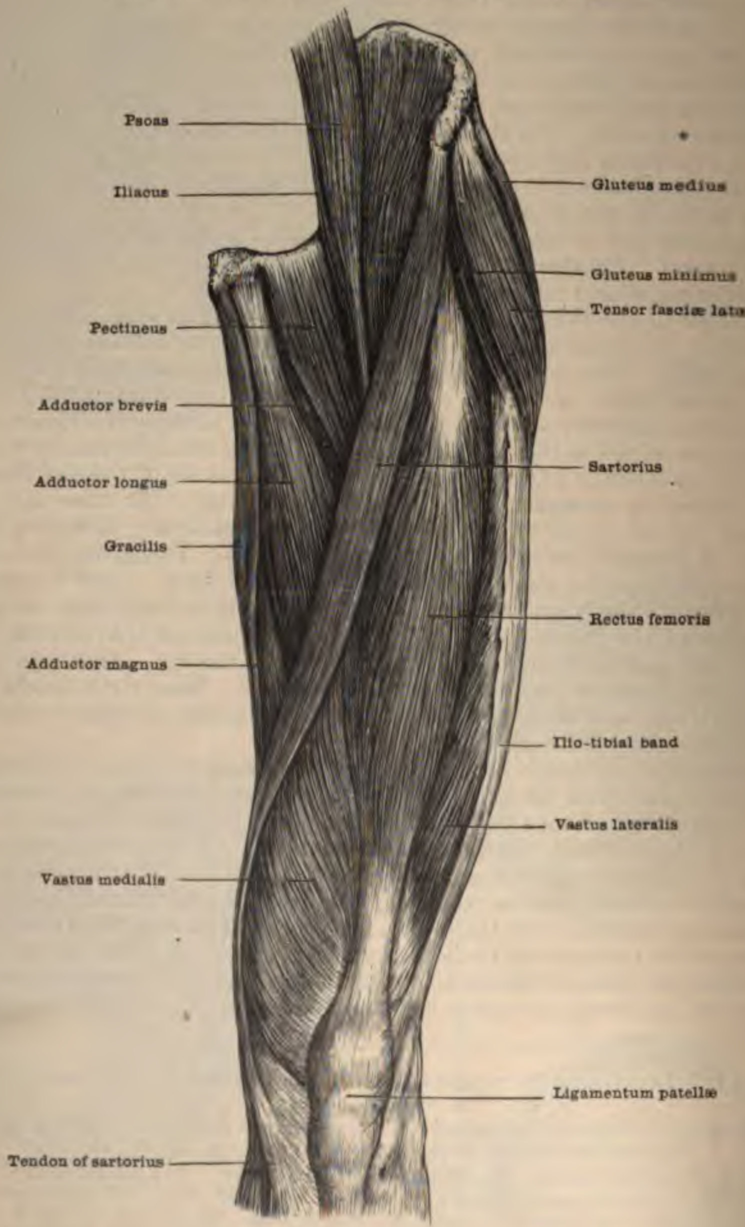
FIG. 357, A - D.—TRANSVERSE SECTIONS THROUGH THE LEFT THIGH IN THE REGIONS INDICATED IN THE DIAGRAM.

a and *b* in the diagram indicate the regions through which pass sections A and B, fig. 354 (p. 428); a' the region through which passes section A, fig. 361 (p. 450).

1. Lateral circumflex artery. 2. Medial circumflex artery. 3. Femoral artery. 4. Deep femoral artery. 5. Inferior gluteal (sciatic) artery. 6. Popliteal artery. 7. Bursa præpatellaris subfascialis. 8. Adductor (Hunter's) canal. 9. Fascia lata. 10. Femur—a, distal extremity. 11. Spermatic cord. 12. Adductor brevis. 13. Adductor longus. 14. Adductor magnus. 15. Biceps femoris—a, long head; b, tendon of origin; c, short head. 16. Gastrocnemius—a, lateral head; b, medial head. 17. Gluteus maximus. 18. Gracilis—a, tendon. 19. Rectus femoris—a, tendon. 20. Sartorius. 21. Semimembranosus—a, tendon. 22. Semitendinosus—a, tendon. 23. Sphincter ani. 24. Vastus intermedius (crureus)—a, tendon. 25. Vastus lateralis—a, tendon. 26. Vastus medialis—a, tendon. 27. Anterior femoral cutaneous nerve. 28. Posterior femoral cataneous (small sciatic) nerve. 29. Inferior gluteal nerve. 30. Obturator nerve—a, superficial branch; b, deep branch. 31. Peroneal (external popliteal) nerve. 32. Saphenous (great saphenous) nerve. 33. Tibial (internal popliteal) nerve. 34. Patella. 35. Lateral intermuscular septum. 36. Medial intermuscular septum. 37. Ilio-tibial band. 38. Femoral vein. 39. Popliteal vein. 40. Great saphenous vein.

medial **lacuna vasorum,** which contains the femoral artery and vein Medial the vein is the **femoral ring,** bounded medially by the **lacunar (Gimberna** **ligament.** This is closed off from the abdominal cavity by a septum derived f the transversalis fascia, the **femoral septum,** but offers passage for lymph-ves

FIG. 358.—MUSCLES OF THE FRONT OF THE THIGH.


Psoas
Iliacus
Pectineus
Adductor brevis
Adductor longus
Gracilis
Adductor magnus
Vastus medialis
Tendon of sartorius
Gluteus medius
Gluteus minimus
Tensor fasciæ latæ
Sartorius
Rectus femoris
Ilio-tibial band
Vastus lateralis
Ligamentum patellæ

Beyond the inguinal ligament the fasciæ of the ilio-psoas and pectineal mus serve to line a triangular space, the **ilio-pectineal fossa,*** through which run femoral vessels (fig. 354). The sartorius muscle partly overlies the distal lat margin of this fossa. The fascia lata is here reflected from the surface of the sarto to the ilio-psoas fascia, and becomes fused with it. From the medial margin of the sartorius a process of the fascia is continued over the lateral and upper part of the fossa, and is attached to the inguinal and lacunar (Gimbernat's) ligaments (fig. 350). Over the lower extremity of the fossa a process is continued medially into the pectineal fascia. On the medial margin of the fossa the fascia lata is continued directly into the pectineal fascia. The lateral concave margin of the fascia overlying the fossa is called the **falciform margin;** the upper extremity of this, the **superior cornu;** the distal extremity, the **inferior cornu.** The oval space bounded by the margo falciformis is called the **fossa ovalis** (saphenous opening). This is covered by the **fascia cribrosa,** which some consider a deep layer of the tela subcutanea and others a portion of the fascia lata. This fascia cribrosa contains many openings for the passage of blood-vessels and lymphatics. The space which lies medial to the femoral vessels between the femoral ring and the fossa ovalis is called the **femoral canal** (crural canal).

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* This lies within *Scarpa's triangle,* a space bounded by the inguinal (Poupart's) ligam and the sartorius and long adductor muscles.

From the fascia intermuscular septa descend in between the underlying muscles. Of these, the medial and lateral intermuscular septa are the best marked (fig. 357).

The **lateral intermuscular septum** separates the extensor muscles from the hamstring group. It extends from the tendon of the gluteus maximus to the lateral epicondyle. It is composed chiefly of longitudinal fibres and is thickest distally. The vastus lateralis is united to its ventro-lateral surface; the short head of the biceps, to its dorso-medial surface.

It will be noted that this septum serves to divide primarily ventral from primarily dorsal musculature, with the exception of the short head of the biceps, which, though primarily dorsal, occupies a position, perhaps secondarily acquired, with the primarily ventral muscles.

The **medial intermuscular septum** serves to divide the anterior extensor from the medial adductor musculature. It is perhaps simplest in the region immediately distal to the ilio-pectineal fossa (fig. 357 B). Here a well-marked septum may be seen extending to the femur between the sartorius and quadriceps on the one side, and the adductor longus and brevis on the other. The septum here, next the muscles, has on each side a membranous lamina. Between the two laminæ there is a looser tissue in which run blood-vessels and nerves. A fibrous membrane extends between the rectus and sartorius to the septum.

More distally the sartorius comes to overlie the septum (fig. 357 C). The sheath of the sartorius on the lateral margin becomes fused with the fascia of the vastus medialis, and on the medial margin to a membrane that covers the ventral surfaces of the adductor longus and magnus. Beneath the sartorius and between the adductor longus and the vastus medialis is a triangular space bounded by the sheaths of these muscles, and filled with a loose areolar tissue in which run the chief blood-vessels of the thigh. This space, first described by John Hunter, is known as **Hunter's canal,** or the **adductor canal.** Still more distally the vessels with their surrounding fibrous tissue pass through the hiatus tendineus, between the long tendon of the adductor magnus and the femur, to the back of the thigh. The septum here passes behind the posterior surface of the vastus medialis to the femur.

MUSCLES

1. The Anterior Group

(Figs. 358, 359)

This group is composed of the quadriceps femoris and the sartorius muscles.

The **sartorius** is a long, ribbon-like muscle which arises from the anterior superior spine of the ilium and extends along the medial margin of the quadriceps, passing obliquely across the upper part of the thigh, and then descending to the dorso-medial side of the knee, whence its tendon curves forwards to be inserted into the ventro-medial surface of the superior extremity of the tibia.

The **quadriceps femoris** is composed of four muscles differentiated from a common embryonic origin. Of these, the **rectus femoris,** which is attached to the ventro-lateral margin of the ilium by two tendons, is the most superficial and the most completely differentiated. The **vastus lateralis,** which arises from the superior extremity of the ventral surface of the shaft of the femur and from the lateral lip of the linea aspera; the **vastus medialis,** which arises from the medial lip of the linea aspera and from the intertrochanteric line; and the **vastus intermedius** (crureus), which arises between these two and beneath the rectus from the surface of the femur, are less distinctly differentiated from one another. The vastus intermedius and vastus lateralis are partly fused at the insertion, the intermedius and medialis at their origins. From the four muscles arises a tendon which is inserted into the tuberosity (tubercle) of the tibia. In this tendon, which is closely applied to the capsule of the knee-joint, lies a sesamoid bone, the patella.

The sartorius and the rectus serve to flex the thigh; the quadriceps to extend the leg; the sartorius to flex the leg and rotate the thigh outwards.

In the embryo the sartorius has an origin distinct from that of the quadriceps. In the anthropoid apes it is much more developed than in man.

In addition to supplying the muscles of this group, the femoral nerve also gives branches to the iliacus muscle (p. 426) and the pectineus muscle (p. 444).

The sartorius (fig. 358).—*Origin.*—From the anterior superior spine of the ilium and the area immediately below this.

Insertion.—Into the medial surface of the tibia near the tuberosity and into the neighbouring fascia of the leg.

Structure.—The muscle arises by short tendinous strands. The fibre-bundles take a nearly parallel course. The component muscle-fibres are said to be the longest in the body. Near the medial epicondyle of the femur the tendon of insertion makes its appearance on the deep aspect of the muscle. On the superficial surface of the tendon the muscle-fibres are inserted as far as the distal margin of the knee-joint. From there the tendon turns forwards to its insertion.

Nerve-supply.—Usually two branches enter the deep surface of the proximal third of the sartorius. One or both of them may be bound up with an anterior cutaneous nerve passing through the muscle. The first of the branches is distributed chiefly to the lateral and proximal, the second to the medial and distal, portions of the muscle. Within the muscle is a complex plexus.

Action.—(1) To flex the thigh at the hip and rotate it outwards; (2) to flex the leg; (3) to make tense the medial part of the fascia lata.

Relations.—The sartorius lies in a fascial canal bounded by the fascia lata and by intermuscular septa which descend from this. It crosses the rectus femoris, ilio-psoas, the adductor longus and magnus, and the vastus medialis muscles, the femoral vessels and nerve, and the knee. At its insertion its tendon covers the gracilis and semitendinosus.

Variations.—It may arise from the inguinal ligament or be inserted into the fascia lata, the medial epicondyle, or the capsule of the knee-joint. It may be longitudinally divided into two parts. The tendon of the secondary slip is in such instances usually attached to the capsule of the knee-joint, but sometimes is attached to the fascia over the vastus medialis or to the anterior wall of the adductor canal. More frequently the muscle is partly divided proximally or distally. The secondary tendon of origin may arise from the anterior inferior spine, the ilio-pectineal eminence, etc. The muscle is very rarely absent. It may be crossed by a tendinous inscription, or more rarely it is rendered digastric by an intervening tendon.

The quadriceps femoris (figs. 358, 359).—This, as pointed out above, is composed of the rectus femoris and the vastus lateralis, intermedius, and medialis.

The rectus femoris (fig. 358).—*Origin.*—By two tendons. The anterior 'straight' tendon is attached to the anterior inferior spine of the ilium; the posterior 'reflected' tendon to the postero-superior surface of the rim of the acetabulum. The two tendons unite so as to form a small arch above the capsule of the joint.

Structure and Insertion.—From this arch an aponeurotic expansion descends upon the front of the muscle nearly to the middle of the thigh. This expansion is broad above, becomes narrower as it descends, and is continued a short distance as a narrow intramuscular tendon after it disappears from the surface. The tendon of insertion begins on the back of the muscle above the middle of the thigh, expands into a broad aponeurosis, and finally becomes a strong band which is inserted into the proximal border of the patella. The fibre-bundles pass in a bipenniform manner from the back and sides of the tendon of origin to the front and sides of the tendon of insertion.

Nerve-supply.—As a rule, two branches enter the muscle. One of these enters the deep surface of the muscle in its upper fourth, and is distributed mainly to the proximal part of the lateral half. The other enters the medial margin of the muscle near the junction of the proximal and middle thirds, and is distributed chiefly to the medial half and distal portion of the muscle.

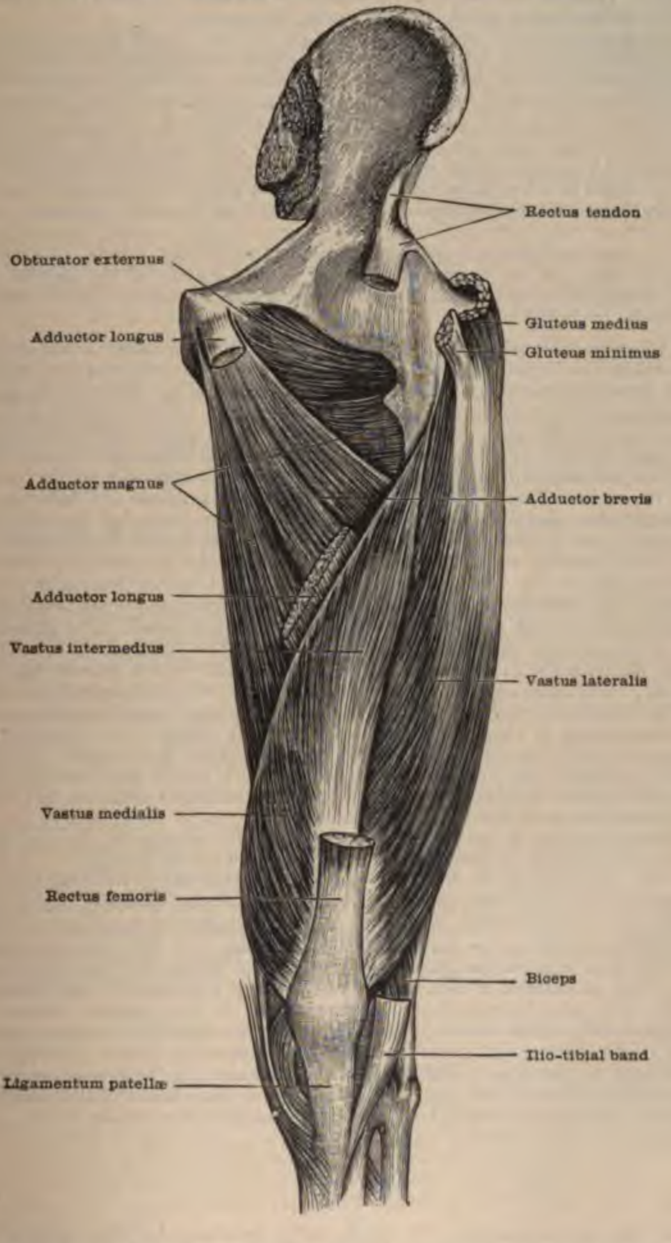
The vastus lateralis (vastus externus) (fig. 359).—*Origin.*—From—(1) the shaft of the femur along the antero-inferior margin of the great trochanter and in front of the gluteal tuberosity; and (2) the lateral intermuscular septum along the upper half of the linea aspera.

Insertion.—By a flat tendon into—(1) the proximo-lateral border of the patella; and (2) the front of the lateral condyle of the tibia and the fascia of the leg.

Structure.—The fibre-bundles arise partly from the bone, partly from an aponeurosis which covers the proximal two-thirds of the muscle, and from the lateral intermuscular septum. They take a parallel course distally in a ventro-medial direction, and are inserted into an aponeurosis which lies on the deep surface of the muscle and receives fibres until within a few centimetres of the patella. Ventrally this aponeurosis fuses with the rectus tendon, laterally with that of the vastus medialis, and dorsally it receives some of the fibre-bundles of the vastus intermedius. Commonly the muscle is distinctly divisible for the greater part of its course into two sheets, a superficial and a deep. The deep sheet is often subdivided into two laminæ.

Nerve-supply.—Usually there are three nerves, one of which, accompanied by blood-vessels, runs on the inner surface of the superficial sheet midway between the tendons of origin and insertion, the second between the two laminæ of the deep layer, and the third passes through the innermost lamina to be distributed in part to the vastus intermedius (crureus) muscle.

FIG. 359.—THE DEEP MUSCLES OF THE FRONT OF THE THIGH.


Rectus tendon
Obturator externus
Adductor longus
Gluteus medius
Gluteus minimus
Adductor magnus
Adductor brevis
Adductor longus
Vastus intermedius
Vastus lateralis
Vastus medialis
Rectus femoris
Biceps
Ilio-tibial band
Ligamentum patellæ

The vastus medialis (vastus internus) (fig. 359).—*Origin.*—From the whole extent of the medial lip of the linea aspera and from the distal half of the intertrochanteric line. The origin takes place by means of an aponeurosis which is adherent to the tendons of insertion of the adductor muscles.

Structure and Insertion.—The fibre-bundles arise from the deep surface of this aponeurosis and are inserted on the medial surface and margin of a tendon which begins on the deep surface of the muscle about its middle near the lateral margin. On the distal lateral border of the muscle it is inserted into the medial half of the proximal margin of the patella and into the medial condyle of the tibia and the fascia of the leg. For some distance near the knee the lateral margin of the tendon is united to those of the vastus intermedius (crureus), lateralis (externus) and the rectus.

Nerve-supply.—The nerve to this muscle descends on its medial surface, often bound up with the saphenous nerve for a part of its course. It gives off successive branches and finally sinks into the muscle substance. These branches enter about midway between the origin and insertion of the fibre-bundles of the muscle.

The vastus intermedius (crureus) (figs. 356, 359).—*Origin.*—From (1) the distal half of the lateral margin of the linea aspera and its lateral bifurcation; (2) the antero-lateral surface of the shaft of the femur. Between the origin of the vastus intermedius (crureus) and that of the vastus medialis the shaft of the femur is free from muscle attachment.

Structure and Insertion.—On the ventral surface of the muscle lies an aponeurosis which extends from its proximal fourth to the proximal margin of the patella. The fibre-bundles of the muscle are inserted into the deep surface of this and into the deep surface of the aponeurosis of insertion of the vastus lateralis. The proximal fibre-bundles descend vertically, the medial and lateral, especially the latter, obliquely to their insertion. Medially the tendon is more or less fused with that of the vastus medialis, and laterally with that of the vastus lateralis. The muscle is composed of muscle lamellæ superimposed concentrically about the shaft of the femur. The deepest, most distal of these is called the **articularis genu** (subcrureus). The fibre-bundles of this layer are inserted into the capsule of the joint or into the superior margin of the patella.

Nerve-supply.—Several branches are usually distributed to this muscle. To the lateral region a branch from the nerve to the vastus lateralis is usually given; to the middle of the muscle another branch descends from the femoral (anterior crural) nerve; to the medial portion there extend several twigs from the nerve to the vastus medialis.

Tendon of the quadriceps.—The quadriceps tendon may be more or less distinctly divided into layers, of which the superficial layer belongs to the rectus, the deep to the vastus intermedius, and the intermediate to the vastus lateralis and medialis. Some of the more superficial fibres of the tendons of the two vasti, however, cross in front of the rectus tendon. The combined tendon of the quadriceps is in part attached to the superior and lateral margins of the patella, and in part extends over the patella into the patellar ligament. A part of the tendon fibres of the vastus lateralis and medialis run on each side of the patella to the ventral surface of the condyles of the tibia. These form the **retinacula patellæ mediale** and **laterale.** The medial is the broader and better developed. With the retinacula are included bundles of fibres which run from the epicondyles to the patella and into which some muscle fibre-bundles are inserted. From the apex of the patella to the tuberosity of the tibia the quadriceps tendon is continued as the **patellar ligament** (fig. 362).

Nerve-supply.—The relations of the branches of distribution to the various parts of the muscle have been pointed out above in connection with each head. The general relations of these branches of the femoral nerve are as follows:—From the femoral nerve near the proximal end of the vastus medialis the branches for the vastus lateralis, vastus intermedius (crureus), and rectus pass distally and laterally between the rectus and vastus intermedius (crureus) to be distributed to the muscles named, while the chief nerve for the vastus medialis descends on the medial side of this muscle in company with the saphenous nerve. The branches to the vastus lateralis and intermedius are commonly bound up in a single nerve-trunk for some distance. The branches to the rectus are usually bound up with this trunk for a shorter distance. The nerve to the vastus medialis may be united to this trunk for a slight distance, but more frequently it is more or less bound up with the saphenous nerve.

Action.—The quadriceps is the extensor of the leg. The rectus femoris also flexes the thigh at the hip. The articularis genu makes tense the capsule of the knee-joint.

Relations.—The quadriceps is covered ventrally immediately by the fascia lata. The sartorius runs along its medial margin; the tensor fasciæ latæ lies over the proximal quarter of its lateral surface. Dorsal to the vastus lateralis lie the gluteus maximus and biceps; dorso-medial to the vastus medialis, the three adductor muscles and the semimembranosus. Next the vastus medialis lies the adductor canal with the femoral vessels and the saphenous nerve.

Variations.—The variations of this muscle, aside from a greater or less fusion of its parts, are not marked. The attachment of the rectus femoris to the anterior inferior spine, which takes place in the embryo later than its insertion above the acetabulum, may be wanting. On the other hand, this tendon may extend to the anterior superior spine. Occasionally the deep reflected tendon may be wanting. The **rectus accessorius** is a fasciculus rarely found, which arises by a tendon from the rim of the acetabulum and is inserted into the ventral edge of the vastus lateralis. It is innervated by a twig from the branch to the rectus.

Bursæ

B. m. recti femoris (superior).—A small bursa between the deep tendon of the rectus femoris and the edge of the acetabulum. Rare. **B. m. recti femoris (inferior).**—Between the tendon of the rectus and the combined tendon of the vastus lateralis and medialis. Occasional. **B. præpatellaris subtendinea.**—A bursa between the tendon of the quadriceps and the periosteum of the patella. Of the three præpatellar bursae,—the subcutaneous, subfascial, and subtendinous,—as a rule only one occurs. When two or three exist, they usually communicate freely with one another. **B. suprapatellaris.**—A bursa between the anterior surface of the lower end of the femur and the tendon of the quadriceps. It usually communicates with the joint cavity. **B. infrapatellaris profunda.**—A bursa between the patellar ligament and the tibia. It seldom communicates with the joint cavity. **B. m. sartorii propria.**—A bursa, fairly large, between the tendon of the sartorius and the tendons of the semitendinosus and gracilis muscles. This usually communicates with the bursa anserina (see p. 446).

2. The Medial (Adductor) Group

(Figs. 356, 358, 359)

To this group of muscles belong the gracilis, the pectineus, the adductor brevis, longus, and magnus, and the obturator externus. The most superficial of the group is the **gracilis** (figs. 355, 358). This ribbon-shaped muscle arises from the inferior pubic and ischial rami, extends along the medial side of the thigh, and gives rise to a tendon which curves forwards from behind the medial condyle of the femur to be inserted under the tendon of the sartorius into the medial side of the upper extremity of the tibia. The quadrilateral **pectineus** arises from the body and superior ramus of the pubis; the triangular **adductor longus** from the superior ramus medial to this (fig. 358). The pectineus is inserted into the pectineal line of the femur; the adductor longus into the middle third of the linea aspera. The triangular **adductor brevis** (fig. 359) arises from the inferior pubic ramus below the adductor longus. It is inserted into the pectineal line and the upper third of the linea aspera. The large, triangular **adductor magnus** (figs. 356, 359) arises from the inferior ramus and the tuber of the ischium and is inserted behind the short and long adductors into the whole length of the linea aspera, and by a special tendon into the adductor tubercle of the femur. The deepest muscle of the group, the **obturator externus,** arises from the outer surface of the bone bounding the ventral two-thirds of the obturator foramen, and is inserted by a tendon into the trochanteric (digital) fossa.

All the muscles of this group adduct the thigh, and most of them rotate it outwards. Those attached to the pubis flex the thigh. The gracilis flexes the leg. The adductor magnus extends the thigh.

The muscles of this group are supplied by the obturator nerve, except the pectineus, which usually gets its whole supply from the femoral (anterior crural) nerve, and the adductor magnus, which gets a part of its supply from the sciatic nerve. In embryonic development the pectineus arises in close conjunction with the obturator group, and in the adult it may get the whole or a part of its nerve-supply from the obturator nerve or from the accessory obturator nerve. In the lower mammals the nerve-supply may come from the femoral (anterior crural) or the obturator nerve or from both. It is not certain whether the innervation from the femoral nerve indicates that the muscle belongs phylogenetically, if not ontogenetically, with the primitive dorsal musculature of the limb. By some it is considered to be derived in part from the primitive dorsal, in part from the primitive ventral, musculature. The adductor magnus arises in the embryo as two distinct portions, one connected with the flexor group of muscles, the other with the adductor group. These two portions later become fused. Primitively the sciatic portion of the adductor magnus and the semimembranosus constitute a single medial flexor muscle.

The gracilis (figs. 355, 358).—*Origin.*—By a flat tendon from the medial margin of the inferior ramus of the pubis and the pubic extremity of the inferior ramus of the ischium.

Structure and Insertion.—The nearly parallel fibre-bundles which arise between two laminæ of the tendon form a thin band of muscle which is narrower and thicker distally than proximally. They are inserted on a tendon which begins as an aponeurosis on the posterior border and medial surface of the muscle in the distal third of the thigh, becomes free as a rounded cord a little proximal to the medial condyle of the femur, runs behind the condyle, and then turns forwards to be inserted by an expanded process into the tibia below the medial condyle.

Nerve-supply.—The nerve enters the deep surface of the muscle near the junction of the superior and middle thirds.

Action.—To adduct the thigh and flex the leg. With the knee flexed, it acts as an internal rotator of the leg.

Relations.—It occupies a position beneath the fascia lata and superficial to the adductor brevis, longus, and magnus muscles. Distally the sartorius lies in front, the semimembranosus behind. Its tendon crosses the tibial collateral ligament of the knee-joint and the tendons of the semitendinosus and the semimembranosus, and is overlapped by that of the sartorius.

Variations.—The pubic origin of the muscle may be much reduced or may be double. Its tendon of insertion may give rise to an accessory fasciculus which extends distally in the leg. In some of the apes the tendon descends normally much farther down the leg than in man.

The pectineus (fig. 358).—*Origin.*—(1) From the pecten (crest) of the os pubis, the bone in front of this, and the pectineal fascia near this origin; and (2) from the anterior margin of the obturator sulcus and from the pubo-capsular ligament. Laterally the two areas of origin are usually separated by most of the superior surface of the body of the pubis. Medially they come together.

Structure and Insertion.—From each area of origin a separate lamina arises. The fibre-bundles of each layer take a nearly parallel course and terminate between two tendinous lamellæ which fuse to be inserted into the upper half of the pectineal line behind the small trochanter. The fibre-bundles of the superficial layer cross those of the deep slightly obliquely. The muscle faces ventrally at its origin, laterally at its insertion.

Nerve-supply.—From a branch of the femoral (anterior crural) nerve, which passes behind the femoral artery and vein and through the pectineal fascia to enter the ventral surface of the muscle. It may also be supplied by the accessory obturator nerve, when present, or by a branch from the obturator. When both the femoral (anterior crural) and obturator nerves supply this muscle, the femoral supplies the superficial, the obturator, the deep lamina (Paterson).

Action.—To flex and adduct the thigh (as in crossing the legs). It is also a weak external rotator.

Relations.—It is covered by the pectineal fascia, lies between the ilio-psoas and the adductor longus muscles, and crosses the obturator externus and adductor brevis muscles. The medial circumflex artery runs between it and the ilio-psoas, the deep femoral artery between it and the adductor longus.

Variations.—The extent of the division of the pectineus into superficial and deep portions varies considerably. It may also be divided into a lateral and a medial division. Often the pectineus is fused with the adductor longus. It may receive an accessory fasciculus from the capsule of the hip-joint, the iliacus muscle, the obturator externus, or the adductor brevis muscles, or the small trochanter. It may send a fasciculus to the sartorius.

The adductor longus (fig. 358).—*Origin.*—From the medial corner of the superior ramus of the pubis by a strong tendon which extends for some distance on the medial border of the muscle.

Structure and Insertion.—From this tendon the fibre-bundles diverge towards their insertion. This takes place between two lamellæ of a short tendon attached to the middle third of the linea aspera. The tendon is usually fused to the medial intermuscular septum and sends an expansion to the long tendon of the adductor magnus.

Nerve-supply.—A branch from the anterior division of the main obturator trunk gives off several twigs which enter the middle third of the deep surface of the muscle. Occasionally a small branch from the femoral (anterior crural) nerve enters the muscle. This is probably sensory in nature.

Action.—To adduct and flex the thigh and rotate it outwards.

Relations.—The sartorius, the vastus medialis, and the femoral vessels lie antero-lateral to it. Behind it lie the adductor brevis and adductor magnus muscles. Between these and the longus run the profunda vessels. Its lateral border touches the pectineus above, but is separated from it towards the insertion.

Variations.—It may be fused with the other adductors, including the pectineus. It may be doubled. The femoral insertion may extend to the medial epicondyle.

The adductor brevis (fig. 359).—*Origin.*—From the medial part of the outer surface of the inferior ramus of the pubis directly, and by means of short tendinous processes or a short flat tendon.

Structure and Insertion.—From their origin the fibre-bundles diverge into a sheet which is inserted by short tendinous bands into the distal two-thirds of the pectineal line and the upper third of the linea aspera. The muscle is more or less completely divided into two fasciculi near its insertion. The place of division is near where the intertrochanteric line curves away from the linea aspera.

Nerve-supply.—Usually from the anterior but also sometimes from the posterior branch of the main obturator trunk. The rami enter the middle third of the muscle near the proximal border.

Action.—It is chiefly an adductor and to a less extent an external rotator of the thigh.

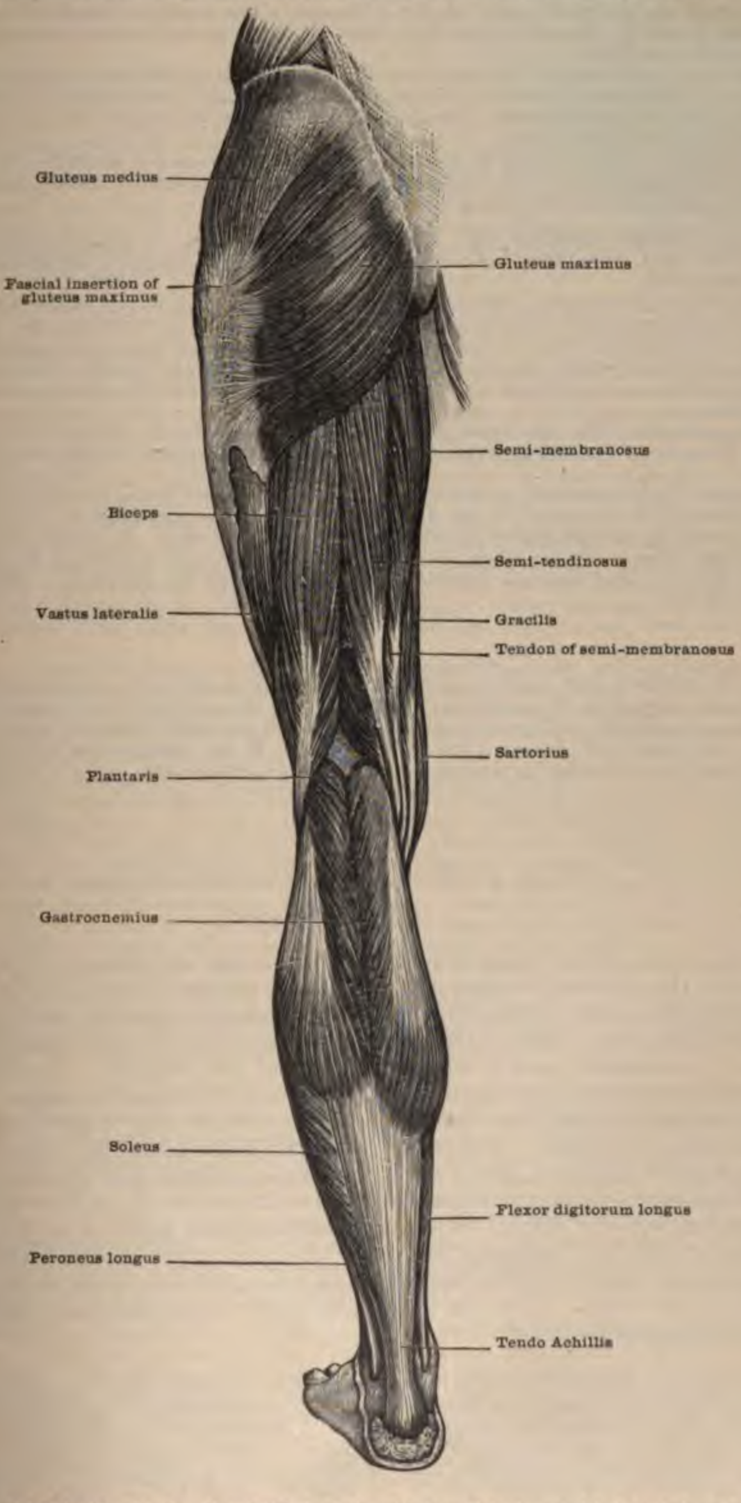
Relations.—In front lie the pectineus and adductor longus; behind, the obturator externus quadratus femoris and adductor magnus. It is crossed by the profunda artery. The first perforating artery passes usually between the two fasciculi of the insertion.

Variations.—It may be fused with other members of the group. It may be divided completely into two fasciculi, rarely into three.

The **adductor magnus** (figs. 356, 359).—The *origin* of this muscle begins on the inferior ramus of the pubis posterior to the origins of the adductor brevis and gracilis muscles. From here it extends backwards along the inferior margin of the ventro-lateral surface of the ischium to the tuberosity. The muscle in passing from this curved origin to its extensive femoral insertion presents posteriorly a longitudinal groove in which rest the hamstring muscles. The adductor magnus is composed of three superimposed fasciculi, of which the first is frequently fairly distinct and is called the **adductor minimus,** while the other two are normally fused, but are occasionally distinct.

The **superior fasciculus (adductor minimus)** *arises* directly from the inferior rami of the pubis and ischium. From here the fibres diverge to form a thin sheet *inserted* by tendinous bands to the medial side of the gluteal ridge and the superior part of the linea aspera. The **middle fasciculus** *arises* directly from the inferior margin of the ventro-lateral surface of the inferior ramus and the tuber of the ischium, and from a tendon which descends along the dorso-medial margin of the muscle from the tuber ischii. The fibre-bundles diverge to be *inserted* between the lamellæ of a narrow flat tendon attached to the distal three-fourths of the linea aspera. This tendon is pierced by the perforating vessels. The **inferior fasciculus** *arises* dorsal to and in common with the middle fasciculus. The fibre-bundles converge towards a strong tendon which begins in the distal third of the thigh and is *inserted* into a tubercle at the distal end of the medial supracondylar ridge.

Fig. 360.—Superficial Muscles of the Back of the Thigh and Leg.


Gluteus medius
Gluteus maximus
Fascial insertion of gluteus maximus
Semi-membranosus
Biceps
Semi-tendinosus
Vastus lateralis
Gracilis
Tendon of semi-membranosus
Sartorius
Plantaris
Gastrocnemius
Soleus
Flexor digitorum longus
Peroneus longus
Tendo Achillis

Nerve-supply.—The chief nerve-supply is from the posterior ramus of the obturator. This enters by one or more branches the proximal portion of the ventral surface of the muscle about midway between its pubic and femoral attachments. It also receives a branch from the sciatic which enters the dorsal surface of the muscle in the middle third of the thigh. To the adductor minimus a branch may be sent from the nerve to the quadratus femoris.

Action.—It is the strongest of the adductors. The superior and middle fasciculi rotate the thigh outwards; the inferior inwards, when the thigh has been rotated outwards. The latter also extends the thigh.

Relations.—In front are the pectineus, the short and long adductor and the vastus medialis muscles, and the profunda artery. Behind lie the hamstring muscles and the gluteus maximus. Medially lies the gracilis muscle. The femoral and perforating arteries pass through its attachment to the shaft of the femur.

Variations.—The divisions of the muscle may be more or less distinct. It may be partly fused or exchange fasciculi with neighbouring muscles—the semimembranosus, quadratus femoris, adductor brevis, and adductor longus.

The **obturator externus** (figs. 354, 356).—*Origin.*—From the lateral surface of the pubic and ischial rami, where they bound the obturator foramen, and from the surface of the obturator membrane.

Structure and Insertion.—Often the muscle is distally divided into three fasciculi, a superior from the superior pubic ramus, a middle from the inferior pubic ramus and the obturator membrane, and an inferior from the ischium. The fibre-bundles converge upon a tendon which is at first deeply buried, then appears on the lateral surface of the muscle and is continued as a rounded tendon over the capsule of the joint to its insertion into the dorsal part of the trochanteric fossa.

Nerve-supply.—The obturator nerve gives rise, usually in the obturator canal, to a branch which bifurcates to enter the superior border and ventral surface of the muscle in its middle third.

Action.—It is a powerful external rotator of the thigh and is also a weak adductor.

Relations.—It is covered by the pectineus, the ilio-psoas, and the adductor magnus muscles in front, and by the quadratus femoris behind near its insertion. It covers over the obturator membrane. The obturator nerve passes either above the muscle or through its upper portion.

Variations.—The reported variations are few. It may be joined by a slip from the adductor brevis.

BURSÆ

B. m. pectinei.—A small bursa frequently present between this muscle and the ilio-psoas and small trochanter. **B. anserina.**—A fairly large bursa which lies between the tendons of the sartorius, gracilis, and semitendinosus muscles and the tibial collateral ligament of the knee-joint. (See also B. M. Sartorii Propria, p. 443.) **B. m. obturatoris externi.**—A bursa is sometimes found between the tendon of this muscle and the capsule of the hip-joint.

3. THE POSTERIOR (HAMSTRING) GROUP

(Figs. 355, 360)

The muscles of this group are the semitendinosus, semimembranosus, and biceps. They flex the knee and extend the hip. The semitendinosus and the long head of the biceps constitute a superficial layer; the semimembranosus and the short head of the biceps a deep layer. The **semitendinosus** and the **long head of the biceps** arise by a common tendon from the tuber of the ischium. The somewhat fusiform semitendinosus gives rise to a tendon in the lower half of the thigh. The tendon curves forwards behind the knee to be inserted under that of the sartorius into the medial side of the tibia. The penniform **short head of the biceps** arises from the linea aspera in the lower part of the thigh, and is inserted, together with the fusiform long head, into a tendon that passes over the lateral side of the knee and is attached to the head of the fibula. The **semimembranosus** arises from the tuber ischii through a long, flat, triangular tendon. The belly of the muscle increases in thickness towards the knee. It is inserted by a strong tendon on the back of the medial condyle of the tibia. From the tendons of all the hamstring muscles expansions are sent into the crural fascia.

The femoral head of the biceps is characteristic of the anthropoid apes and man. In many mammals its place is taken by a slender muscle, the **tenuissimus,** which extends from the caudal vertebræ, the sacro-tuberous (great sacro-sciatic) ligament, or the gluteal fascia to the fascia of the back of the leg. In some forms this muscle is broad instead of slender. According to Testut, the long head of the biceps may be looked upon as arising by two fasciculi, one primitively attached to the posterior part of the ilium, the other to the caudal vertebræ or coccyx. The sacro-tuberous (great sacro-sciatic) ligament represents the reduced upper portion of this muscle. In the fœtus the origin of the muscle extends higher on the sacro-tuberous ligament than in the adult. In many of the lower mammals the origins of the semimembranosus and semitendinosus take place in part from the sacro-caudal vertebræ.

In the mammals below man the insertion of the biceps, gracilis, and semitendinosus takes place chiefly into the fascia of the back of the leg, and extends more distally than in man. This insertion of these flexor muscles is associated with a permanent position of flexion of the leg at the knee. In the human embryo likewise these muscles are inserted more distally than in the adult. In the lower primates the semimembranosus is chiefly an internal rotator of the leg.

The biceps (Figs. 355, 360).—**Long head.**—*Origin.*—From a tendon common to it and the semitendinosus. This tendon arises from the more medial of the two facets on the back of the tuber of the ischium and from the sacro-tuberous (great sacro-sciatic) ligament. It is continued for a third of the distance to the knee as a septum between the biceps and the semitendinosus, and for a short distance as an aponeurotic sheath on the deep surface of the biceps.

Structure and Insertion.—The fibre-bundles begin to arise from the tendon some distance from the ischium. They form a thick fusiform belly which is inserted into the deep surface of a tendon that begins laterally on the back of the muscle about the middle of the thigh. The insertion of the fibre-bundles of the long head continues on the medial margin of the deep surface of the tendon nearly as far as the lateral condyle of the femur.

Short head.—*Origin.*—By short tendinous fibres from the lateral lip of the linea aspera of the femur from the middle of the shaft to the bifurcation of this line, the proximal two-thirds of the supracondylar ridge, and the lateral intermuscular septum.

Structure and Insertion.—The fibre-bundles take a nearly parallel course, to be inserted on the deep surface of the common tendon of insertion. The most distal fibres are inserted nearly to the skeletal attachment of the tendon. The tendon is inserted into the superior extremity of the head of the fibula, into the lateral condyle of the tibia, and into the fascia of the leg.

Nerve-supply.—Commonly two branches are given to the long head of the biceps. One of these branches is given off proximal to the ischium, and enters the proximal third of the deep surface of the muscle. The other is given off more distally and usually enters the middle third. Either or both branches may be doubled or the two may be combined for some distance in a common trunk. The nerve-fibres arise usually from the first, second, and third sacral nerves. The branch to the short head arises from the peroneal (external popliteal) portion of the sciatic nerve about the middle of the thigh. It enters the posterior surface near the lateral margin of the muscle, and passes distally across the muscle bundles about midway between the tendons of origin and insertion. The nerve-fibres come chiefly from the fifth lumbar, first and second sacral nerves.

Action.—To extend the thigh and flex the leg. The short head acts only on the leg. The long head acts as an outward rotator of the thigh, and of the leg when flexed.

Relations.—The upper extremity of the muscle is covered by the gluteus maximus. Below this the long head and tendon of insertion lie beneath the fascia lata and overlie the short head. Ventral to the muscle lie the tendon of origin of the semimembranosus, the adductor magnus and vastus lateralis muscles, and the lateral head of the gastrocnemius. The medial border is in contact with the semitendinosus and semimembranosus. Distally it forms the upper lateral border of the popliteal space. The sciatic nerve runs between it and the adductor magnus.

Variations.—The short head is rarely absent. It may be more isolated from the long head than usual, and at times has a separate tendon of insertion. It may itself be divided into two distinct laminæ. Its origin may take place higher up on the femur than usual or from the fascia lata. Variations of this sort suggest the tenuissimus muscle of some of the lower mammals (see above). The long head of the biceps may receive accessory fasciculi from the coccyx, sacrum, sacro-tuberous (great sacro-sciatic) ligament, tuber of the ischium, or the deep surface of the gluteus maximus. These fasciculi suggest the iliac and sacro-coccygeal origin of the muscle found in lower vertebrates (see above). Inferiorly, a muscle fasciculus may take the place of the fibrous prolongations from the tendon of the biceps into the sural fascia (the **tensores fasciæ suralis**). This may extend to the tendon of Achilles. The long head may have a tendinous inscription similar to that of the semitendinosus.

The **semitendinosus** (figs 355, 360).—*Origin.*—Partly from a medio-dorsal facet on the distal margin of the tuber of the ischium by direct implantation of the fibre-bundles, and partly from the medial surface of the tendon common to it and the long head of the biceps.

Structure and Insertion.—The fibre-bundles spread out to form a flat, fusiform belly which, about the middle of the thigh, again contracts towards the tendon of insertion. This begins on the medial margin and dorsal surface of the muscle, becomes free from the muscle slightly above the medial condyle of the femur, passes behind this and curves forwards to be inserted by a triangular expansion into the proximal part of the medial surface of the tibia behind and distal to the insertion of the gracilis. An aponeurotic expansion is continued into the fascia of the thigh. About the middle of the muscle a narrow irregular tendinous inscription more or less completely divides the belly into proximal and distal divisions.

Nerve-supply.—To the muscle two nerves are commonly given. One arises from the sciatic nerve or directly from the plexus, proximal to the tuber of the ischium, sometimes in company with a branch to the long head of the biceps. It enters the middle third of the deep surface of the proximal portion of the muscle. The other branch arises from the sciatic nerve, usually distal to the ischial tuber, sometimes in common with a nerve to the biceps or the semimembranosus. It enters about the middle of the deep surface of the distal half of the muscle. Either or both branches may be represented by two nerves. The nerve fibres of the first branch arise chiefly from the first and second sacral nerves, those of the second from the fifth lumbar and first sacral nerves.

Action.—To extend the thigh and flex the leg, and with knee flexed, to rotate the leg inwards.

Relations.—It is covered by the gluteus maximus and fascia lata; on the lateral side lies the biceps; and in front, the semimembranosus and adductor magnus.

Variations.—It may be completely separated from the biceps at its origin. It may be fused with neighbouring muscles. There may be two tendinous inscriptions. It may have a femoral head (a condition characteristic of many birds). A muscle fasciculus may extend from the body of the muscle to the fascia of the back of the leg.

The **semimembranosus** (fig. 355).—*Origin.*—By a long, flat tendon which lies beneath the proximal half of the semitendinosus, and which arises from the more lateral of the two facets on the back of the tuber of the ischium, between the tendons of the biceps and the quadratus femoris. The tendon is at first adherent to the tendon of the adductor magnus in front and to that of the biceps and semitendinosus behind. It descends to the middle of the muscle.

Structure and Insertion.—From both surfaces of the medial side and distal extremity of the tendon of origin fibre-bundles arise which take an oblique course to their insertion on the aponeurosis of the tendon of insertion. This appears on the deep surface and medial margin of the muscle opposite the end of the tendon of origin and descends on the medial side and deep surface of the muscle. Near the back of the medial condyle of the femur the insertion of muscle-fibres ceases and the tendon is inserted directly on the back of the medial condyle of the tibia, and by aponeurotic expansions into the capsule of the joint, into the lateral condyle of the femur, into the tibial collateral ligament, and into the fascia of the popliteus muscle.

Nerve-supply.—By several branches from the sciatic nerve, which usually arise from a common trunk in company with the branches to the adductor magnus. These branches enter the deep surface of the muscle about midway between the origin and insertion of the constituent fibre-bundles.

Action.—To flex the leg and extend the thigh.

Relations.—It is covered by the gluteus maximus, the long head of the biceps, the semitendinosus, and the fascia lata. It lies dorsal to the quadratus femoris, the adductor magnus, and the knee-joint.

Variations—It may be fused with the semitendinosus or the adductor magnus. It may be doubled. Its tendons may have a more extensive attachment than usual. The extent of the belly of the muscle varies considerably. A muscle fasciculus may be sent into the popliteal space. An extra head may arise from the ischial spine.

BURSÆ

B. m. bicipitis femoris superior.—A fair-sized bursa which frequently lies between the tendon of origin of the long head of the biceps and semitendinosus and the tendon of the semimembranosus and the ischial tuber. **B. m. bicipitis femoris inferior.**—A small bursa which separates the tendon of insertion from the fibular collateral ligament of the knee-joint. **B. m. bicipitis gastrocnemialis.**—A bursa infrequently found between the tendon of the biceps and the tendons of origin of the lateral head of the gastrocnemius and the plantaris muscles. **B. m. semimembranosus.**—This is a large double bursa constantly present. One part extends between the semimembranosus, the medial head of the gastrocnemius, and the knee-joint. With the cavity of the joint it frequently communicates. The other part extends between the tendon of the semimembranosus and the medial condyle of the tibia.

C. MUSCULATURE OF THE LEG AND THE FOOT

(Figs. 360–369)

The musculature of the leg arises in part from the distal end of the femur, but in the main from the tibia and fibula. The muscle-bellies are best developed in the proximal half of the leg, where they give rise to the 'calf' behind and to less well-marked ventral and lateral protrusions. Towards the ankle the muscle-bellies give way to tendons which serve to attach the muscles of the leg to the skeleton of the foot.

The musculature is divisible into a posterior and an antero-lateral group of muscles. These two groups are separated by the tibia and fibula, the interosseous membrane, and by an intermuscular septum which extends from the lateral margin of the shaft of the fibula to the fascia enveloping the leg. Medially the separation is well marked by the broad medial surface of the tibia. Laterally the line of division is not so clearly marked externally. In the proximal part of the leg the dorsal musculature protrudes somewhat ventrally; in the distal part the lateral portion of the antero-lateral musculature passes dorsal to the lower end of the fibula.

The antero-lateral musculature is subdivided into two distinct groups, an anterior and a lateral. The muscles of the **anterior group** (figs. 362, 363) take origin from the tibia and fibula and the interosseous membrane, and give rise to tendons which extend over the ankle to the medial side of the foot (**tibialis anterior**), to the digits (**extensor hallucis longus** and **extensor digitorum longus**), and to the lateral side of the foot (**peroneus tertius**). The **lateral, peroneal, group** (fig. 364) takes origin from the fibula and the lateral part of the upper extremity of the tibia. It is composed of two muscles the tendons of which extend behind the lateral malleolus. That of the **peroneus brevis** passes to the side of the foot, that of the **peroneus longus** across the plantar surface of the tarsus to the first metatarsal. Both groups of muscles are supplied from the peroneal (external popliteal) nerve, which arises from the back of the sacral plexus.

The **posterior musculature** of the leg is divided by a transverse septum into a superficial and a deep group of muscles. In the **superficial group** (fig. 360) are the **gastrocnemius,** which arises by two heads, one on each side from the back of the femur, close above the condyles, and the **soleus,** which arises from the tibia and fibula beneath the gastrocnemius. These form the **triceps suræ,** which is united by the tendon of Achilles to the back of the calcaneus and is the great extensor of the foot. Near the lateral head of the gastrocnemius is found the inconstant little **plantaris** muscle, the slender tendon of which extends to the heel. The **deep group** (fig. 364) is divisible into a proximal muscle, the **popliteus,** which extends from the lateral femoral epicondyle to the back of the tibia, and a more distal set of muscles, one of which arises from the tibia (**flexor digitorum longus**), one from the fibula (**flexor hallucis longus**), and one, the **tibialis posterior,** from the interosseous membrane and the adjacent sides of the tibia and fibula partly under cover of the two preceding muscles. The tendons of the three muscles pass in separate osteo-fibrous canals behind the medial malleolus to the plantar side of the foot. The tendons of the two long flexors terminate on the terminal phalanges of the digits; that of the tibialis posterior has an extensive attachment on the plantar surface of the skeleton of the foot.

In the foot are found the tendons of the crural musculature, special muscles differentiated in association with these tendons, and an intrinsic digital adductor, abductor, flexor, and extensor series of muscles.

On the **dorsum of the foot** the **extensor digitorum brevis** (fig. 363) arises from the lateral side of the tarsus under cover of the long extensor tendons, and is inserted with these into all the toes except the little toe.

In the **sole of the foot** the most superficial muscle is the **flexor digitorum brevis** (fig. 366), which arises from the calcaneus and sends tendons to the second row of phalanges of the four more lateral toes. Beneath this lie the tendons of the long flexor muscles (fig. 367). To the lateral margin of the tendon of the long flexor of the toes is attached the **quadratus plantæ,** which arises from the calcaneus. From the tendons to the four more lateral digits **lumbrical** muscles pass to the medial side of the corresponding toes. On each side of this system of long flexor tendons and associated muscles lie the **abductors** and **short flexors** of the big and little toes, and more deeply placed lie the **adductor** of the big toe and the **interosseous** muscles (figs. 368, 369). These are inserted into the bases of the first row of phalanges and into the extensor tendons.

The extensor digitorum brevis is supplied by a branch from the ramus profundus of the peroneal. All the muscles of the sole of the foot are supplied by the lateral plantar nerve except the flexor digitorum brevis and the flexor brevis and abductor hallucis, which are supplied by the medial plantar nerve.

While in the forearm the extensor-supinator muscles extend proximally on the radial side of the arm to the humerus, and the flexor-pronator muscles on the ulnar side, in the leg both of the corresponding sets of muscles extend primitively on the fibular side of the leg to the femur. In the higher vertebrates the superficial layer of the flexor musculature of the leg takes origin from both sides of the distal extremity of the femur, and the origin of the extensor musculature ceases to extend to the femur. The crural musculature is primitively inserted into the bones of the leg, the tarsus, and the aponeuroses of the foot. On the extensor side of the leg the musculature ultimately becomes attached wholly to the foot by means of tendons differentiated, in part at least, from the dorsal aponeurosis. The lateral portion of the extensor musculature, which primitively extends from the femur to the fibula, in the higher vertebrates extends from the fibula to the tarsus and metatarsus (peroneal musculature). On the flexor side of the leg the more superficial musculature maintains a tarsal attachment through the tendon of Achilles. The deeper musculature in part extends from the femur and fibula to the tibia, in part arises from the fibula and tibia, and is inserted into the metatarsus and the digits through tendons differentiated from the plantar aponeuroses. The musculature of the sole of the foot is highly developed in five-toed vertebrates, but in those which walk on the toes, and especially in hoofed animals, it is very greatly reduced.

The **fasciæ** and **ligaments** of the leg and foot and the relations of the musculature may be followed in the cross sections shown in figs. 361 and 365.

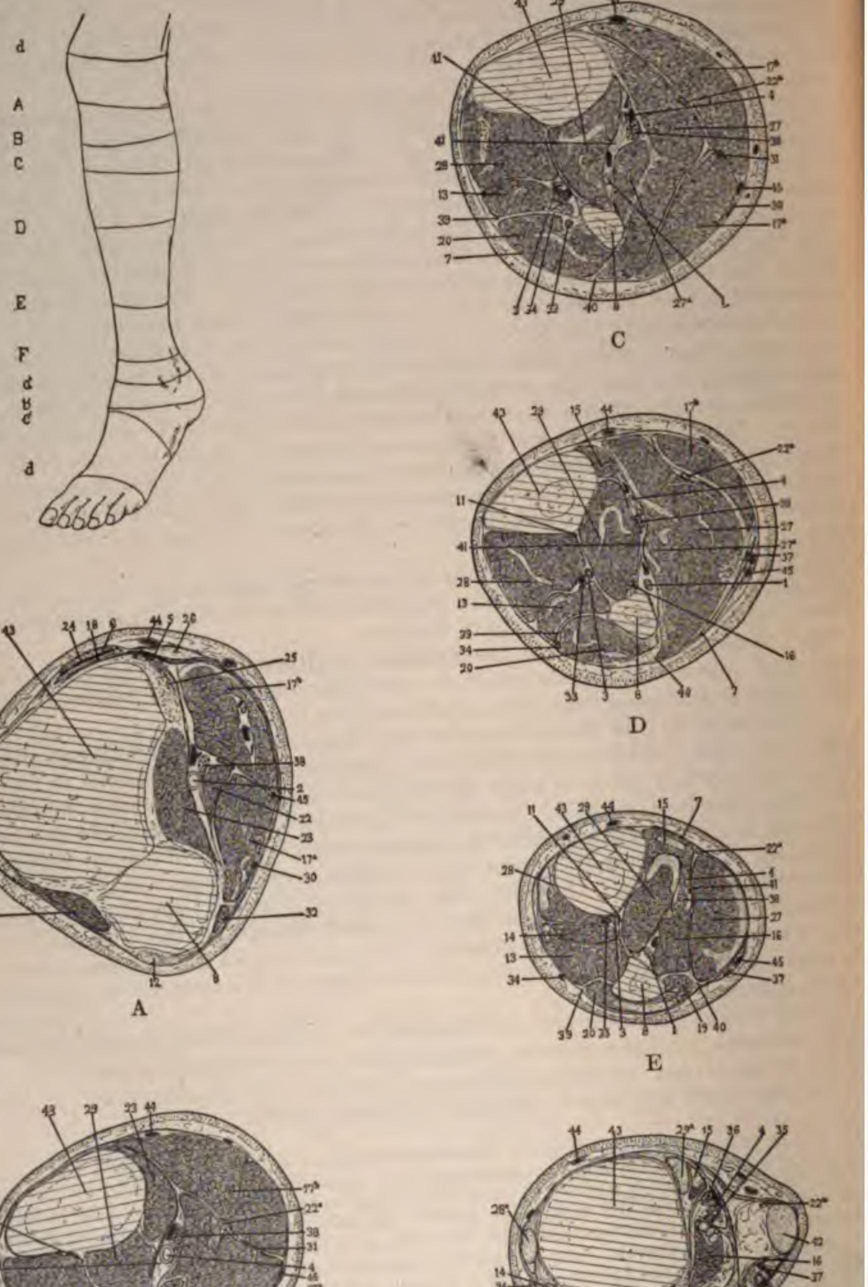

d
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FIG. 361.

The **tela subcutanea** of the leg contains a considerable amount of fat where it ove lies the muscles, but less where it overlies the bones and joints. Subcutaneou bursæ are found over the tuberosity of the tibia (**b. subcutanea tuberositatis tibiæ** and over each of the malleoli (**b. subcutanea malleoli medialis et lateralis**). Ove the dorsum of the foot the tela contains comparatively little fat, but on the sole of th foot and plantar surface of the toes it contains much fat interposed between dense fibrous tissue. The **b. subcutanea calcanea** lies beneath the tuber calcanei.

The **crural fascia,** or external layer of fascia of the leg, extends from the knee to the ankle. It forms an enveloping cone-like sheath for the muscles and is adherent to the periosteum of the medial surface of the tibia. It is formed of transverse, oblique, and longitudinal fibres and is thickest in front.

Ventrally the fascia of the thigh, to which the tendons of the quadriceps, sartorius, gracilis, semitendinosus, and biceps muscles and the ilio-tibial band are closely united, becomes attached with these tendons to the tibia and fibula. From these attachments, therefore, the fascia of the front of the leg may be said to arise. Into it extend processes from the tendons mentioned. Dorsally the fascia of the thigh is continued uninterruptedly into that of the leg. Distally the crural fascia is attached to the two malleoli and to the posterior surface of the calcaneus.

In the proximal part of the leg in front the underlying muscles in part take origin from the fascia; in other places the fascia is separated from the underlying muscles by loose tissue.

From the fascia two main intermuscular septa arise. One, the **anterior intermuscular septum,** extends between the extensor digitorum longus and peroneal muscles to the anterior crest of the fibula; the other, the **posterior intermuscular septum,** between the peroneal muscles and the soleus to the lateral crest of the fibula. These septa separate compartments for the anterior, lateral, and posterior groups of muscles.

As the heads of the gastrocnemius pass over the back of the knee they are held in place by a special deep lamina of the fascia lata, which distally becomes fused with the crural fascia (fig. 361 A).

The semimembranosus has a special fascial investment which, on the back of the knee, becomes bound on each side of the muscle and its tendon to the capsule of the joint. This fascia extends into a transverse septal membrane which is continued over the deep muscles of the back of the leg to the ankle. It is united on one side to the tibia, on the other to the fibula. Proximally the fibres are continued into it from the tendon of the semimembranosus. Over the back of the tibia the septum is interrupted by the attachment of the soleus to the popliteal line. Beyond the tibial origin of the soleus it is fused on the medial side of the flexor digitorum longus to the crural fascia.

In addition to the two intermuscular septa and the longitudinal transverse septum, other septa serve to separate the individual muscles of the different groups.

Above the ankle the fascia is enforced by bands of tissue so that ligaments are formed which serve to retain in position the various tendons which pass from the leg into the foot.

FIG. 361, A-F.—TRANSVERSE SECTIONS THROUGH THE LEFT LEG IN THE REGIONS SHOWN IN THE DIAGRAM.

d In the diagram indicates the region through which passes section D, fig. 357 (p. 436); *a′*, *b′*, *c′*, *d′*, the regions through which pass sections A, B, C, D, fig. 365 (p. 464).

1 Peroneal artery. 2. Popliteal artery. 3. Anterior tibial artery. 4. Posterior tibial artery. 5. Bursa anserina. 6. Bursa m. sartorii propria. 7. Crural fascia. 8. Fibula. 9. Transverse crural ligament. 10. Patellar ligament. 11. Interosseous membrane. 12. Biceps femoris—tendon. 13. Extensor digitorum longus—a, tendon. 14. Extensor hallucis longus. 15. Flexor digitorum longus. 16. Flexor hallucis longus. 17. Gastrocnemius—a, lateral head; b, medial head. 18. Gracilis tendon. 19. Peroneus brevis. 20. Peroneus longus—a, tendon. 21. Peroneus tertius. 22. Plantaris—a, tendon. 23. Popliteus. 24. Sartorius, tendon. 25. Semimembranosus, tendon. 26. Semitendinosus, tendon. 27. Soleus—a, fasciculus accessorius. 28. Tibialis anterior—a, tendon. 29. Tibialis posterior—a, tendon. 30. Lateral sural cutaneous nerve. 31. Medial sural cutaneous nerve. 32. Common peroneal (external popliteal) nerve. 33. Deep peroneal (anterior tibial) nerve. 34. Superficial peroneal nerve. 35. Lateral plantar nerve. 36. Medial plantar nerve. 37. Sural (external saphenous) nerve. 38. Tibial (posterior tibial) nerve. 39. Anterior intermuscular septum. 40. Posterior intermuscular septum. 41. Transverse sural septum. 42. Tendo Achillis (calcanei). 43. Tibia. 44. Great saphenous vein. 45. Small saphenous vein.

The **transverse crural ligament** (upper part of anterior annular ligament) (fig. 362) lies on the front of the lower part of the leg above the ankle. It is composed of fascia strengthened by transverse bundles which pass from the medial side of the tibia to the ventral margin of the fibula. From its deep surface a strong, broad septum descends to the tibia and divides the underlying space into two osteo-fibrous canals, a medial for the tibialis anterior and a lateral for the long extensor muscles. The lateral compartment is further subdivided by a slightly marked septum into a medial division for the extensor hallucis longus and a lateral for the extensor digitorum longus and the peroneus tertius.

The **cruciate ligament** (lower part of anterior annular ligament) (fig. 362) serves to hold the tendons of the anterior muscle group in place as they pass to the dorsum of the foot. In part it is formed by a dense fibrous band lying in the fascia over the ankle, in part of a ligament which passes from the bones of the ankle to the deep surface of this band. The superficial band is V-shaped. It arises from the lateral surface of the body of the calcaneus and passes across the dorsum of the foot, one arm of the V going to the medial malleolus, the other to the side of the foot, where it terminates in the fascia over the first cuneiform bone. The apex of the V lies over the tendons of the extensor digitorum longus and peroneus tertius muscles. The distal arm extends over the tendons of the extensor hallucis longus and tibialis anterior muscles. The proximal arm passes over the tendon of the extensor hallucis longus and then divides into two layers, between which the tendon of the tibialis anterior passes. The deeper ligament mentioned above arises from deep within the tarsal sinus, some of its fibres even from the sustentaculum tali. It then passes forwards and medially beneath the long extensor tendons, and divides into two parts, one of which curves about the medial margin of the tendon of the extensor digitorum longus, the other about the extensor hallucis longus tendon to the under surface of the proximal arm of the V-shaped band.

The **peroneal retinacula** are strengthened regions in the fascia which serve to hold the tendons of these muscles in place. The **superior** extends from the lateral malleolus into the fascia on the back of the leg, and to the lateral surface of the calcaneus. The **inferior** overlies the tendons on the lateral surface of the calcaneus, and is attached to this bone on each side of them. Between the tendons it sends a septum to the bone. It is connected with the superficial layer of the cruciate ligament.

The **laciniate ligament** (internal annular) (fig. 364) is found on the medial side of the ankle. Here the fascia is strengthened by fibre-bands which form a well-marked ligament that serves to hold in place the tendons of the deep dorsal cruro-pedal muscles. This ligament extends from the dorsal and distal margins of the medial malleolus to the calcaneus. It is closely bound to the tibia and the talo-tibial (tibio-astragaloid) ligament until the tendon of the tibialis posterior is reached. It passes over this and becomes bound to the bony structures on the posterior margin of the tendon. From this attachment two layers, a deep and a superficial, extend backwards. The superficial layer extends to the tuber calcanei, and is connected superiorly with the crural fascia. The deep layer, which represents a continuation distally of the transverse septum, extends over the tendons of the flexor digitorum longus and flexor hallucis longus to the medial surface of the calcaneus, and is closely united to the underlying bone on each side of these tendons, thus giving rise to osteo-fibrous canals.

Fasciæ of the foot.—Over the **dorsum** of the foot a fascial membrane extends from the cruciate ligament mentioned above to the toes, where it is continued as fibrous sheaths for the extensor tendons. Laterally and medially it is continued into the plantar fascia. Where it overlies skeletal structures it becomes adherent to them. In the main this fascial sheet is thin. Over the base of the first metatarsal it is strengthened by a band which runs from the medial side of this bone over the extensor tendons of the big toe to the base of the second metatarsal. The extensor digitorum brevis is covered by an adherent fascial sheet. The dorsal surface of each dorsal interosseous muscle is likewise covered by an adherent membrane.

The **plantar surface** of the foot is invested by a fascia in which three distinct regions may be observed, a central, a lateral, and a medial. The central region is greatly thickened by bands of fibrous tissue, the **plantar aponeurosis,** which diverge towards the toes from the medial half of the tuber calcanei. These bands become distinct from one another as the toes are approached, and each finally terminates partly in the skin over the head of the corresponding metatarsal and in the digital sheath of the flexor tendons. Some of the fibres are continued into the transverse capitular ligaments, the others extend through near the metatarsophalangeal articulation to the dorsum of the foot. Broader, thicker bands go to the three middle toes than to the big and little toes. At the margins of this central area some fibres radiate into the fascia of the lateral and medial areas, some extend laterally into the skin, and some sink into the intermuscular septa described below. Near the toes well-marked transverse bundles of fibres may be seen between the digital bands. The central area of the plantar fascia is not densely adherent to the skin.

The digital sheaths of the flexor tendons of the toes correspond essentially with those previously described (p. 392) for the fingers.

The **medial plantar fascia** is thin and adherent to the skin. It extends between the central plantar and the dorsal fascia over the intrinsic muscles of the big toe. The **lateral plantar fascia** is thick and well developed near the heel, thin as the little toe is approached. A dense band, the **calcaneo-metatarsal ligament,** strengthens it between the calcaneus and the tuberosity of the fifth metatarsal.

At the junction of the lateral with the central region of the plantar fascia the **lateral intermuscular septum** sinks in to be attached to the first cuneiform, the navicular and the tendon of the posterior tibial. A similar **medial intermuscular septum** sinks in between the medial and central regions of the plantar fascia and is attached to the long plantar ligament, the tendon sheath of the peroneus longus and the base of the fifth metatarsal. The fascia of each of these regions in considerable part extends into these septa instead of becoming continuous across them.

The sole is thus divided into three great fascial compartments by these septa, a lateral, a central, and a medial. In the lateral lie the intrinsic pedal muscles of the little toe; in the medial, the abductor and the flexor brevis of the big toe and the distal end of the tendon of the flexor hallucis longus. The central compartment is subdivided by transverse septa into several sub-compartments. In the most superficial compartment lies the flexor digitorum brevis; in the second, the tendons of the flexor digitorum longus and its associated muscles, the quadratus plantæ (flexor accessorius) and the lumbrical muscles; in the third, the adductor muscles of the big toe; and in the fourth, the interosseous muscles.

The first two sub-compartments are most clearly marked in the region of the tarsus. Distally they become merged by the disappearance of the intervening transverse septum, and longitudinally subdivided by fibrous septa which serve to make a complete sheath over each digit for the flexor tendons. The sheath over the adductor muscle of the big toe is a thin membrane continued laterally from the medial intermuscular septum. Where the two heads of the adductor muscle advance upon their tendon of insertion, the medial septum has no skeletal attachment, so that the adductor sub-compartment of the middle fascial compartment communicates freely with the medial compartment. Over the cuneiform bones the tendon of the flexor hallucis longus passes from the long flexor region of the middle compartment into the medial compartment. Here the medial intermuscular septum divides into two layers, which form a sheath for the tendon as it passes to the plantar surface of the flexor hallucis brevis.

1. Muscles of the Front of the Leg

(Figs. 362, 363)

The anterior musculature of the leg consists of four muscles, the tibialis anterior, extensor digitorum longus, peroneus tertius, and extensor hallucis longus. The **tibialis anterior** has a quadrangular prismic belly which arises from the lateral side of the tibia and adjacent interosseous membrane in the proximal half of the leg. The tendon passes over the front of the tibia to the medial side of the foot. The **extensor digitorum longus** is a transversely flattened, fusiform muscle, which arises from the superior extremity of the tibia, the medial margin of the fibula, and the adjacent interosseous membrane, and gives rise to a tendon which passes over the front of the distal extremity of the tibia and sends tendons to the two terminal phalanges of the four more lateral toes. The **peroneus tertius** represents a more or less completely differentiated portion of the preceding muscle. Its tendon passes laterally through the same osteo-fibrous canal in the same synovial sheath and terminates on the lateral side of the foot. The **extensor hallucis longus** is a narrow

The **transverse crural ligament** (upper part of anterior annular ligament) (fig. 362) lies on the front of the lower part of the leg above the ankle. It is composed of fascia strengthened by transverse bundles which pass from the medial side of the tibia to the ventral margin of the fibula. From its deep surface a strong, broad septum descends to the tibia and divides the underlying space into two osteo-fibrous canals, a medial for the tibialis anterior and a lateral for the long extensor muscles. The lateral compartment is further subdivided by a slightly marked septum into a medial division for the extensor hallucis longus and a lateral for the extensor digitorum longus and the peroneus tertius.

The **cruciate ligament** (lower part of anterior annular ligament) (fig. 362) serves to hold the tendons of the anterior muscle group in place as they pass to the dorsum of the foot. In part it is formed by a dense fibrous band lying in the fascia over the ankle, in part of a ligament which passes from the bones of the ankle to the deep surface of this band. The superficial band is V-shaped. It arises from the lateral surface of the body of the calcaneus and passes across the dorsum of the foot, one arm of the V going to the medial malleolus, the other to the side of the foot, where it terminates in the fascia over the first cuneiform bone. The apex of the V lies over the tendons of the extensor digitorum longus and peroneus tertius muscles. The distal arm extends over the tendons of the extensor hallucis longus and tibialis anterior muscles. The proximal arm passes over the tendon of the extensor hallucis longus and then divides into two layers, between which the tendon of the tibialis anterior passes. The deeper ligament mentioned above arises from deep within the tarsal sinus, some of its fibres even from the sustentaculum tali. It then passes forwards and medially beneath the long extensor tendons, and divides into two parts, one of which curves about the medial margin of the tendon of the extensor digitorum longus, the other about the extensor hallucis longus tendon to the under surface of the proximal arm of the V-shaped band.

The **peroneal retinacula** are strengthened regions in the fascia which serve to hold the tendons of these muscles in place. The **superior** extends from the lateral malleolus into the fascia on the back of the leg, and to the lateral surface of the calcaneus. The **inferior** overlies the tendons on the lateral surface of the calcaneus, and is attached to this bone on each side of them. Between the tendons it sends a septum to the bone. It is connected with the superficial layer of the cruciate ligament.

The **laciniate ligament** (internal annular) (fig. 364) is found on the medial side of the ankle. Here the fascia is strengthened by fibre-bands which form a well-marked ligament that serves to hold in place the tendons of the deep dorsal cruro-pedal muscles. This ligament extends from the dorsal and distal margins of the medial malleolus to the calcaneus. It is closely bound to the tibia and the talo-tibial (tibio-astragaloid) ligament until the tendon of the tibialis posterior is reached. It passes over this and becomes bound to the bony structures on the posterior margin of the tendon. From this attachment two layers, a deep and a superficial, extend backwards. The superficial layer extends to the tuber calcanei, and is connected superiorly with the crural fascia. The deep layer, which represents a continuation distally of the transverse septum, extends over the tendons of the flexor digitorum longus and flexor hallucis longus to the medial surface of the calcaneus, and is closely united to the underlying bone on each side of these tendons, thus giving rise to osteo-fibrous canals.

Fasciæ of the foot.—Over the **dorsum** of the foot a fascial membrane extends from the cruciate ligament mentioned above to the toes, where it is continued as fibrous sheaths for the extensor tendons. Laterally and medially it is continued into the plantar fascia. Where it overlies skeletal structures it becomes adherent to them. In the main this fascial sheet is thin. Over the base of the first metatarsal it is strengthened by a band which runs from the medial side of this bone over the extensor tendons of the big toe to the base of the second metatarsal. The extensor digitorum brevis is covered by an adherent fascial sheet. The dorsal surface of each dorsal interosseous muscle is likewise covered by an adherent membrane.

The **plantar surface** of the foot is invested by a fascia in which three distinct regions may be observed, a central, a lateral, and a medial. The central region is greatly thickened by bands of fibrous tissue, the **plantar aponeurosis,** which diverge towards the toes from the medial half of the tuber calcanei. These bands become distinct from one another as the toes are approached, and each finally terminates partly in the skin over the head of the corresponding metatarsal and in the digital sheath of the flexor tendons. Some of the fibres are continued into the transverse capitular ligaments, the others extend through near the metatarsophalangeal articulation to the dorsum of the foot. Broader, thicker bands go to the three middle toes than to the big and little toes. At the margins of this central area some fibres radiate into the fascia of the lateral and medial areas, some extend laterally into the skin, and some sink into the intermuscular septa described below. Near the toes well-marked transverse bundles of fibres may be seen between the digital bands. The central area of the plantar fascia is not densely adherent to the skin.

The digital sheaths of the flexor tendons of the toes correspond essentially with those previously described (p. 392) for the fingers.

The **medial plantar fascia** is thin and adherent to the skin. It extends between the central plantar and the dorsal fascia over the intrinsic muscles of the big toe. The **lateral plantar fascia** is thick and well developed near the heel, thin as the little toe is approached. A dense band, the **calcaneo-metatarsal ligament,** strengthens it between the calcaneus and the tuberosity of the fifth metatarsal.

At the junction of the lateral with the central region of the plantar fascia the **lateral intermuscular septum** sinks in to be attached to the first cuneiform, the navicular and the tendon of the posterior tibial. A similar **medial intermuscular septum** sinks in between the medial and central regions of the plantar fascia and is attached to the long plantar ligament, the tendon sheath of the peroneus longus and the base of the fifth metatarsal. The fascia of each of these regions in considerable part extends into these septa instead of becoming continuous across them.

The sole is thus divided into three great fascial compartments by these septa, a lateral, a central, and a medial. In the lateral lie the intrinsic pedal muscles of the little toe; in the medial, the abductor and the flexor brevis of the big toe and the distal end of the tendon of the flexor hallucis longus. The central compartment is subdivided by transverse septa into several sub-compartments. In the most superficial compartment lies the flexor digitorum brevis; in the second, the tendons of the flexor digitorum longus and its associated muscles, the quadratus plantæ (flexor accessorius) and the lumbrical muscles; in the third, the adductor muscles of the big toe; and in the fourth, the interosseous muscles.

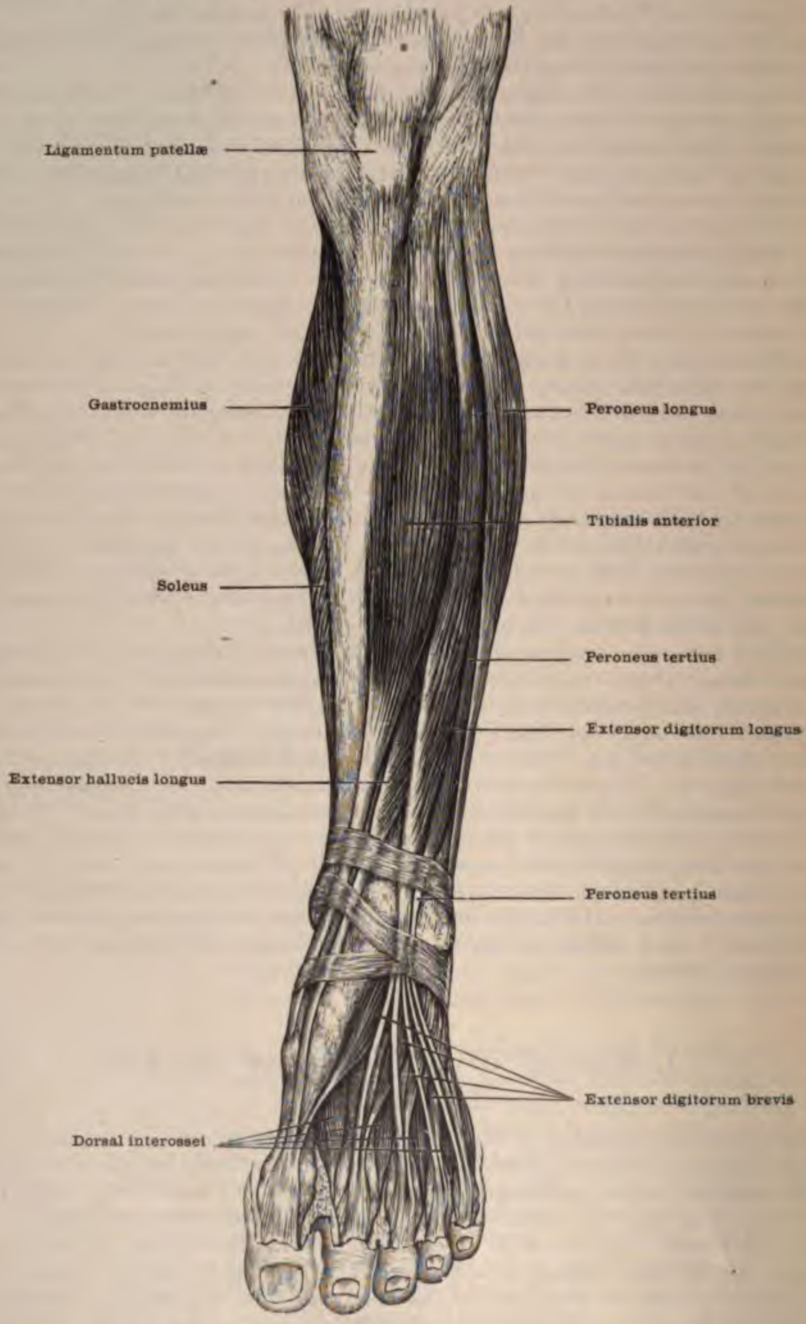
The first two sub-compartments are most clearly marked in the region of the tarsus. Distally they become merged by the disappearance of the intervening transverse septum, and longitudinally subdivided by fibrous septa which serve to make a complete sheath over each digit for the flexor tendons. The sheath over the adductor muscle of the big toe is a thin membrane continued laterally from the medial intermuscular septum. Where the two heads of the adductor muscle advance upon their tendon of insertion, the medial septum has no skeletal attachment, so that the adductor sub-compartment of the middle fascial compartment communicates freely with the medial compartment. Over the cuneiform bones the tendon of the flexor hallucis longus passes from the long flexor region of the middle compartment into the medial compartment. Here the medial intermuscular septum divides into two layers, which form a sheath for the tendon as it passes to the plantar surface of the flexor hallucis brevis.

1. MUSCLES OF THE FRONT OF THE LEG

(Figs. 362, 363)

The anterior musculature of the leg consists of four muscles, the tibialis anterior, extensor digitorum longus, peroneus tertius, and extensor hallucis longus. The **tibialis anterior** has a quadrangular prismic belly which arises from the lateral side of the tibia and adjacent interosseous membrane in the proximal half of the leg. The tendon passes over the front of the tibia to the medial side of the foot. The **extensor digitorum longus** is a transversely flattened, fusiform muscle, which arises from the superior extremity of the tibia, the medial margin of the fibula, and the adjacent interosseous membrane, and gives rise to a tendon which passes over the front of the distal extremity of the tibia and sends tendons to the two terminal phalanges of the four more lateral toes. The **peroneus tertius** represents a more or less completely differentiated portion of the preceding muscle. Its tendon passes laterally through the same osteo-fibrous canal in the same synovial sheath and terminates on the lateral side of the foot. The **extensor hallucis longus** is a narrow muscle which arises from the distal half of the medial surface of the fibula and the interosseous membrane. Its tendon extends over the ankle to the great toe. The tendons of these muscles are held in place by the transverse and cruciate ligaments described above.

FIG. 362.—THE MUSCLES OF THE FRONT OF THE LEG.


Ligamentum patellæ
Gastrocnemius
Peroneus longus
Tibialis anterior
Soleus
Peroneus tertius
Extensor digitorum longus
Extensor hallucis longus
Peroneus tertius
Extensor digitorum brevis
Dorsal interossei

All the muscles of this group flex the foot. The extensors extend the toes; t peroneus tertius and the extensor digitorum longus evert the foot.

The tibialis anterior is represented in the arm probably by the brachio-radialis and the t radial extensors; the extensor digitorum longus by the extensor digitorum communis extensor digiti quinti proprius; and the extensor hallucis longus by the extensor pollicis longus. Two abnormal muscles not infrequently found, the abductor hallucis longus and extensor primi internodii hallucis, represent probably the corresponding normal muscles of the hand.

The tibialis anterior (fig. 362).—*Origin.*—From the distal surface of the lateral condyle of the tibia, and the lateral surface of the proximal half of the shaft of the tibia, the adjacent interosseous membrane, the overlying fascia near the condyle (tuberosity) of the tibia, and the intermuscular septum between it and the extensor digitorum longus.

Structure.—Bipenniform. The fibre-bundles converge upon a flat tendon which begins high in the muscle and emerges on the anterior margin of the muscle about the middle of the leg. On the deep surface the implantation of fibre-bundles continues to the transverse crural (anterior annular) ligament.

Insertion.—The tendon passes over the front of the tibia to the medial side of the foot, where it is inserted into the medial surface of the first cuneiform and the base of the first metatarsal.

Nerve-supply.—As a rule, a branch from the common peroneal (external popliteal) nerve enters the proximal portion of the muscle by several twigs, and another from the deep peroneal (anterior tibial) enters near the middle of the belly on the lateral edge.

Relations.—In the proximal half of the leg the extensor digitorum longus lies lateral to it; and between the two muscles, the anterior tibial artery and vein. It is covered by the crural fascia and rests on the interosseous membrane. Distally it lies over the extensor hallucis longus. The tendon passes in special compartments beneath the transverse and the cruciate (anterior annular) ligaments.

The extensor digitorum longus (fig. 362).—*Origin.*—From the lateral condyle of the tibia, the anterior crest of the fibula, the intermuscular membrane between it and the tibialis anterior, the lateral margin of the interosseous membrane, the septum between it and the peroneus longus, and the fascia of the leg near the tibial origin.

Structure.—Penniform. The fibre-bundles converge upon the posterior surface of a tendon which begins at the middle of the leg. The implantation of fibres continues nearly to the ankle. Usually at the distal margin of the transverse (anterior annular) ligament the tendon divides into two parts which pass between the two layers of the cruciate (lower part of anterior annular) ligament, and then each divides again into two parts, thus giving rise to four slips, one for each of the four lateral toes.

Insertion.—Each tendon on the dorsal surface of the toe to which it goes divides into three fasciculi: an intermediate, which is attached to the dorsum of the base of the second phalanx; and two lateral, which converge to the dorsum of the base of the third phalanx. The margins of the tendon are also bound by fibrous tissue to the sides of the back of the first phalanx.

Nerve-supply.—Most frequently two branches of the deep peroneal (anterior tibial) enter the deep surface of the muscle, one near its tibial origin, one about the center of the belly.

Relations.—In the proximal half of the leg it lies on the interosseous membrane, and beneath the fascia of the leg, and adjoins medially the tibialis anterior, laterally the peroneus longus. Distally it lies over the extensor hallucis longus and adjoins laterally the peroneus brevis. The tendon passes beneath the transverse crural and the superficial layer of the cruciate (anterior annular) ligaments and over the extensor digitorum brevis muscle. The superficial peroneal (musculo-cutaneous) nerve runs in the septum between it and the peroneal muscles; the anterior tibial artery and deep peroneal nerve pass beneath the head of the muscle, and then between it and the tibialis anterior.

The peroneus tertius (fig. 362).—*Origin.*—From the distal third of the medial surface of the fibula, the neighbouring interosseous membrane, and the anterior intermuscular septum.

Structure.—It is essentially a fasciculus of the extensor digitorum longus, from which it is seldom completely differentiated. The fibre-bundles descend obliquely forwards to be inserted in a penniform manner on a tendon which runs along the lateral margin of the tendons of the extensor digitorum. The attachment of fibre-bundles continues to the cruciate ligament (lower part of anterior annular ligament).

Insertion.—On the base of the fifth metatarsal and often also on the base of the fourth.

Nerve-supply.—The more distal nerve to the extensor digitorum continues into this muscle.

Relations.—It lies lateral to the extensor digitorum longus. Its tendon passes into the foot beneath the transverse crural and the superficial layer of the cruciate ligament in the same compartments with those of the extensor longus.

The extensor hallucis longus (fig. 362).—*Origin.*—From the middle two-fourths of the median surface of the fibula near the interosseous crest, and from the distal half of the interosseous membrane.

Structure.—Penniform. The fibre-bundles are attached as far as the cruciate ligament to the back and sides of a tendon which begins on the antero-medial margin of the distal third of the muscle.

Insertion.—On the base of the second phalanx of the big toe. On the back of the first phalanx the margins of the tendon are attached to the bone by bands of fibres.

Nerve-supply.—As a rule, a branch from the deep peroneal (anterior tibial) nerve enters the deep surface of the muscle near the junction of the upper and middle thirds, and passes distally across the middle of the obliquely running muscle fibre-bundles.

Relations.—It lies on the distal half of the interosseous membrane, partly covered by the extensor digitorum longus and the tibialis anterior muscles. Its tendon passes over the front of the distal extremity of the tibia and the medial side of the dorsum of the foot, and is held in place by the transverse and cruciate ligaments and by a strengthening band in the fascia over the base of the first metatarsal. In the distal part of the leg the anterior tibial artery and the deep

3. Lateral Musculature of the Leg

(Figs. 364, 369)

The lateral muscles consist of the peroneus longus and the peroneus brevis. They extend and evert the foot. The thick prismatic belly of the **peroneus longus** arises from the proximal half of the lateral surface of the fibula and from neighbouring structures, while the smaller belly of the **peroneus brevis** arises from the middle third of the lateral surface of this bone. The peroneus longus partly covers the peroneus brevis. The tendons of the two muscles pass behind the lateral malleolus, held in place by special retinacula (p. 454). There the tendon of the peroneus longus lies at first lateral to and then crosses behind that of the peroneus brevis and curves about the lateral side of the calcaneus and across the sole of the foot closely applied to the cuboid and to the tarso-metatarsal articulations, and terminates on the base of the first metatarsal. The tendon of the peroneus brevis terminates on the lateral side of the foot at the base of the fifth metatarsal.

The two muscles are probably represented in the arm by the extensor carpi ulnaris. In some of the lower animals the head of the peroneus longus extends to the femur. The fibular collateral ligament of the knee-joint probably represents in man the femoral head of the peroneus.

The peroneus longus (figs. 364, 369).—*Origin.*—Anterior head: tendinous from the anterior tibio-fibular ligament, the neighbouring part of the lateral condyle of the tibia, and the head of the fibula; fleshy from the proximal third of the anterior intermuscular septum and the crural fascia near the tibia. Posterior head: fleshy from the proximal half of the lateral surface of the shaft of the fibula and from the posterior intermuscular septum.

Structure.—Bipenniform. The fibre-bundles converge upon a tendon which begins high in the muscle. The constituent fibre-bundles of the anterior head are long and take a nearly vertical course. The fibre-bundles of the posterior head take a more oblique course and their attachment extends more distally on the tendon. The tendon emerges on the surface of the muscle in the distal half of the leg. The fibre-bundles of the posterior head extend to within a few centimetres of the lateral malleolus. The tendon passes through the retro-malleolar groove, passes across the lateral face of the calcaneus, to and through the oblique groove of the cuboid, and crosses the second and third tarso-metatarsal joints. Where the tendon enters the groove in the cuboid it contains a fibro-cartilaginous nodule which may become a sesamoid bone.

Insertion (fig. 369).—On the inferior surface of the first cuneiform and on the supero-lateral border and base of the first metatarsal. From the region of the fibro-cartilaginous nodule above mentioned a fibrous slip is usually sent to the base of the fifth metatarsal.

Nerve-supply.—Most commonly the peroneal (external popliteal) nerve before dividing gives off two branches. One of these enters the deep surface of the middle third of the anterior head, the other passes across the middle third of the constituent bundles of the posterior head. The latter branch may arise from the superficial peroneal (musculo-cutaneous) nerve, and it may extend to supply the peroneus brevis.

The peroneus brevis (fig. 364).—*Origin.*—From the middle third of the lateral surface of the fibula; and (2) from the septa which separate it from the anterior and posterior groups of muscles.

Structure.—Penniform. The fibre-bundles converge upon a tendon which begins high in the muscle and becomes visible on the lateral surface of the distal half of the belly. Behind the lateral malleolus the tendon becomes free, then passes forwards below the malleolus and across the calcaneus and cuboid.

Insertion.—Into the tip of the tuberosity of the fifth metatarsal.

Nerve-supply.—The nerve arises from the superficial peroneal (musculo-cutaneous) nerve, or from a branch to the peroneus longus. It enters the proximal margin of the muscle and passes distally across its constituent fibre-bundles.

Relations.—The peroneal muscles in the leg are contained in a compartment bounded by the anterior and posterior intermuscular septa, by the fibula, and by the fascia of the leg. The peroneus longus to a considerable degree overlies the peroneus brevis. Beneath the upper part of the peroneus longus the peroneal (external popliteal) nerve bifurcates into its two chief branches. The deep peroneal (anterior tibial) nerve passes medially beneath the anterior head of the muscle. The superficial peroneal (musculo-cutaneous) nerve extends in the interval between the areas of the attachment of the two heads of the peroneus longus, and along the anterior margin of the peroneus brevis to the anterior intermuscular septum, through which it passes to its superficial distribution. The tendon of the peroneus longus at first lies lateral to and slightly overlaps that of the peroneus brevis. Towards the tip of the malleolus it lies almost directly posterior to this tendon. On the lateral surface of the calcaneus the tendon of the brevis lies superior to that of the longus, from which it is separated by a bony spine, the processus trochlearis of the calcaneus. The tendon of the longus is separated from the deep surface of the abductor of the little toe, and is held in place in the groove in the cuboid by the long plantar liagment.

Action.—The peroneus brevis everts the foot. The peroneus longus extends, abducts, and everts the foot, and supports the arch of the foot. The peroneus brevis also extends the foot when this is greatly flexed.

Variations.—The two peroneal muscles may be more or less fused. The origin of the peroneus longus may extend to the femur. The two heads of origin may be fused. Its tendon of insertion may send slips to the second, third, and rarely to the fourth and fifth metatarsals. The tendon may be united to that of the tibialis posterior (12 out of 45 bodies—Picou). Sesamoid cartilages or bones are occasionally found in the retro-malleolar and calcaneal portions of the tendon. The tendon of the peroneus brevis may send a slip to the second or third phalanx or to the head of the metatarsal of the fifth toe, to its extensor tendon, or to the cuboid. It may also send a fasciculus to the fourth metatarsal or the extensor tendon of the fourth toe.

Accessory Peroneals

Poirier considers these all varieties of a muscle which in its simplest form arises from the distal fourth of the fibula and is inserted by a tendon into the fifth toe. A corresponding muscle is normally found in many of the monkeys (**peroneus digiti quinti**). In man in one form or another it is a frequent anomaly. It may be so fused with the peroneus brevis that only its tendon of insertion is apparent. It may appear as a special muscle fasciculus of the peroneus longus or brevis. It may be merely a tendinous band, or it may be tendinous at origin and insertion, with an intermediate belly. Instead of being attached to the fifth toe, it may be inserted into the fifth metatarsal, the cuboid, the tendon of the peroneus longus, the calcaneus, lateral malleolus, or posterior talo-fibular ligament.

Synovial Tendon-sheaths

Vagina tendinum peroneorum communis.—There is a double sheath for the tendons of the peroneal muscles as they pass back of the lateral malleolus. From this region of union the sheath sends processes along each tendon proximally above the malleolus and distally over the lateral surface of the calcaneus. This process on the tendon of the peroneus longus often communicates with the following sheath. **Vagina tendinis m. peronæi longi plantaris.**—This sheath begins in the peroneal groove of the cuboid and ends near the medial border of the long plantar ligament.

4. Musculature of the Back of the Leg

a. Superficial Group (fig. 360)

To this group belong the gastrocnemius, soleus, and plantaris muscles. They serve to extend the foot and flex the leg. The two ovoid heads of the **gastrocnemius** arise one on each side from above the condyles of the femur, extend about to the middle of the back of the leg, and are inserted into the posterior surface of the tendon of Achilles, and through this into the back of the calcaneus. The broad, flat, ovoid **soleus** arises beneath the gastrocnemius from the tibia and fibula, and is inserted into the deep surface of the tendon of Achilles as far as the ankle. The two heads of the gastrocnemius and the soleus constitute the **triceps suræ.** The **plantaris** is a slender muscle which passes along the medial margin of the lateral head of the gastrocnemius and beneath the medial head, where it gives rise to a slender tendon that runs between the gastrocnemius and soleus and along the medial margin of the tendon of Achilles to the fatty fibrous tissue of the heel.

The muscles of this group have a common embryonic origin, and are first differentiated on the fibular side of the leg, whence they extend over the posterior tibial vessels and nerve to their medial attachments. The gastrocnemius corresponds with the flexor carpi radialis and ulnaris, the plantaris with the palmaris longus, the soleus with a portion of the flexor digitorum sublimis of the forearm. In many of the monkeys and in the prosimians the plantaris is much more developed than in man.

The gastrocnemius (fig. 360).—**Medial Head.**—*Origin.*—From a facet on the back of the medial condyle of the femur above the articular surface, from an area on the back of the femur superior and lateral to this, and from the femoral margin of the capsule of the knee-joint. **Lateral Head.**—*Origin.*—From a facet on the proximal portion of the postero-lateral surface of the lateral condyle of the femur and from a rough area situated more medially and at a greater distance from the joint.

Structure and Insertion.—The heads of the gastrocnemius are similar in structure. From the condylar facets there descend aponeurotic bands, one on the medial margin and the medial side of the posterior surface of the medial head, the other on the lateral margin and the lateral side of the posterior surface of the lateral head. These bands descend about two-thirds of the way down the muscle. In the tendon of the lateral head a sesamoid bone is frequently found. The fibre-bundles of the muscle pass obliquely from the supracondylar areas of origin and from the deep surface of the aponeurosis on each side to the tendon of insertion. This tendon begins as a septum between the two heads, and as a lamina on the deep surface of each head. The septum and laminæ soon fuse with the broad aponeurosis which covers the dorsal surface of the soleus.

The attachment of fibre-bundles continues to about the middle of the back of the leg. The attachment of the medial head extends more distally than that of the lateral head. As a rule, the medial head is also the broader and thicker of the two.

The soleus.—*Origin.*—(1) By a fibular head from the back of the head and the proximal third of the posterior surface of the shaft of the fibula, and from the intermuscular septum between it and the peroneus longus; and (2) by a tibial head from the transverse septum over the distal margin of the popliteus, from the popliteal line, and from the middle third of the medial border of the tibia.

Structure and Insertion.—From the fibular and tibial origins arise broad aponeuroses which unite proximally on the deep surface of the muscle so as to form a fibrous arch over the posterior tibial vessels and nerves. Distally they diverge and become more narrow, but the fibular aponeurosis is continued on the fibular side and the tibial aponeurosis on the tibial side of the muscle as far as the distal quarter of the leg. The main portion of the belly of the muscle is formed by fibre-bundles which arise from the posterior surface of these aponeuroses and pass obliquely to be inserted in a bipenniform manner on the deep surface of the tendon of Achilles. This tendon begins as a broad aponeurosis which covers the greater part of the posterior surface of the muscle, and gradually converges into a heavy fibrous band that is inserted into the calcaneus. The bundles of fibres of the tendon take a slightly spiral course. Those on the posterior surface run from the medial margin towards the lateral surface of the calcaneus; those on the anterior surface in a reverse direction. The attachment of the fibre-bundles continues to within a short distance of the heel. A few of the fibre-bundles arise directly from the fibula and the posterior intermuscular septum. On the deep surface of the belly of the muscle there is an **accessory fasciculus** which is formed by fibre-bundles that spring on each side from the anterior surface of the aponeuroses of origin of the muscle and have a bipenniform insertion on each side of a thin, oblique tendinous lamina which inferiorly becomes united to the deep surface of the tendon of Achilles.

The plantaris (fig. 360).—This muscle **arises** from the distal part of the lateral line of bifurcation of the linea aspera, in close association with the lateral head of the gastrocnemius. The fibre-bundles give rise to a flat, short, fusiform belly, and are united to a narrow tendon which extends along the medial edge of the tendon of Achilles to the lateral part of the dorsal surface of the calcaneus, where it **terminates** in the neighbouring fibrous tissue.

Nerve-supply.—From the tibial (internal popliteal) part of the sciatic nerve in the popliteal space nerves arise for each head of the gastrocnemius. Each nerve enters the middle third of the deep surface of the head near the proximal margin. The nerve-supply for the soleus is from two sources. One nerve arises in the popliteal space, often in company with the nerve to the lateral head of the gastrocnemius. It enters the posterior surface of the muscle near the proximal border and divides into two branches, one for each head of the muscle. The tibial (posterior tibial) nerve gives rise to a branch which, about half-way down the leg, enters the deep surface of the muscle and furnishes branches for the deep portion of the muscle on each side. The nerve-supply of the plantaris is by a branch from the tibial (internal popliteal) portion of the sciatic. This arises in the popliteal space and enters the deep surface of the muscle.

Relations.—The semimembranosus winds about the medial margin of the medial head of the gastrocnemius to its deep surface. The biceps passes to the lateral side of the lateral head of the gastrocnemius, and the plantaris along its medial margin. The semimembranosus and biceps above, the medial head of the gastrocnemius and the plantaris below, bound the popliteal space. The peroneal (external popliteal) nerve passes from the popliteal space obliquely across the plantaris and the lateral head of the gastrocnemius. The medial sural (short saphenous) nerve and the small saphenous vein pass between the heads of the gastrocnemius to the surface and thence to the lateral side of the ankle. From the peroneal (external popliteal) nerve in the popliteal space the lateral sural (communicans peronei) nerve extends distally over the calf. The (posterior) tibial nerve and posterior tibial artery and vein run between the two heads of the gastrocnemius, and then beneath the soleus to the medial side of the ankle. In the region of the tendon of Achilles a considerable space filled with fatty tissue intervenes between the tendon and the transverse septum.

Action.—The contraction of the triceps suræ produces extension, adduction, and inversion of the foot. The gastrocnemius is also a flexor of the leg. The plantaris has no known function in man. In some animals it is an extensor of the plantar fascia.

Variations.—There is considerable variation in the extent of the separation of the different parts of the triceps suræ. The tendons of the three heads may be separate nearly to the heel. Either or both heads of the gastrocnemius or the soleus may be doubled. A slip from the biceps or semimembranosus, from the linea aspera, or popliteal space may join the triceps and give rise to a quadriceps suræ. On the other hand, one of the heads of the gastrocnemius or the tibial head of the soleus may be missing. A supernumerary fasciculus may extend from the deep surface of the soleus to the calcaneus. The plantaris is exceedingly variable in origin, structure, and insertion. The origin may be from the capsule of the knee-joint, the fascia of the leg, or from the tibia. Its tendon may terminate at almost any part of its course in neighbouring structures. It may be represented by a fibrous band. It is absent in about 7 per cent. of instances (Le Double).

BURSÆ

B. m. gastrocnemii lateralis.—A bursa is often found between the tendon of the lateral head of the gastrocnemius and the capsule of the joint. It may communicate with the joint cavity. **B. m. gastrocnemii medialis.**—A bursa usually lies between the tendon of origin of the medial head of the gastrocnemius, the condyle of the humerus, and the capsule of the joint. Another bursa (b. m. semimembranosi) extends between the semimembranosus and the medial head of the gastrocnemius muscle. The two bursæ frequently communicate with one another and with the joint. **B. tendinis calcanei.**—This lies between the tendon of Achilles and the upper part of the back of the calcaneus. Between the back of the tendon and the crural fascia another bursa is frequently present.

b. DEEP GROUP

The deep posterior musculature is separated from the superficial by the transverse septum described above (p. 451). The muscles covered by this septal fascia are the **popliteus,** the **flexor digitorum longus,** the **flexor hallucis longus,** and the **tibialis posterior.** An intermuscular septum between the popliteus and the tibialis posterior, and the attachment of the soleus to the popliteal line on the back of the tibia serve to separate the popliteus from the other deep posterior muscles which lie distal to this region and send tendons into the sole of the foot. The deep posterior musculature may thus be considered as divided into a proximal femoro-tibial and a distal cruro-pedal group.

Femoro-tibial Muscle

The popliteus (fig. 364).—A triangular muscle which *arises* from an ovoid facet at the inferior extremity of the groove on the outer side of the lateral condyle of the femur and is *inserted* into the proximal lip of the popliteal line of the tibia and the surface of the shaft of the tibia proximal to this.

Structure.—From the origin a broad tendon glides over the condyle within the capsule of the joint, then over the lateral fibro-cartilage and through a groove on the back of the tibio-fibular articulation. From both surfaces of this tendon, fibre-bundles diverge towards the area of insertion. The tendon is more or less intimately united to several structures with which it comes in contact about the joint. Rarely it contains a sesamoid bone. The fibres of insertion terminate in part in the fascia covering the muscle. The popliteus is homologous with the pronator teres of the arm, or, according to some investigators, with the deep portion of that muscle.

Nerve-supply.—A nerve which arises either independently or in conjunction with that to the posterior tibial muscle enters the popliteus near the middle of its distal edge. Sometimes a branch from the chief nerve to the knee-joint enters the proximal edge of the muscle.

Action.—To flex and rotate the leg medially.

Relations.—The popliteus lies within a compartment bounded by the transverse septum, the capsules of the knee and superior tibio-fibular joints, the back of the tibia, and a septum extending to the popliteal line (see above). On the transverse septum run the popliteal vessels and the tibial nerve. The proximal margin of the soleus overlaps the distal margin of the popliteus. The synovial membrane of the knee-joint sends a prolongation between its tendon and the back of the lateral condyle of the tibia.

Variations.—It is rarely absent. An accessory head may arise from the medial side of the lateral condyle or from some neighbouring structure. The **fibulo-tibialis** (peroneo-tibialis) is a small muscle found by Gruber in one body in seven. It arises from the medial side of the head of the fibula and is inserted into the posterior surface of the tibia beneath the popliteus.

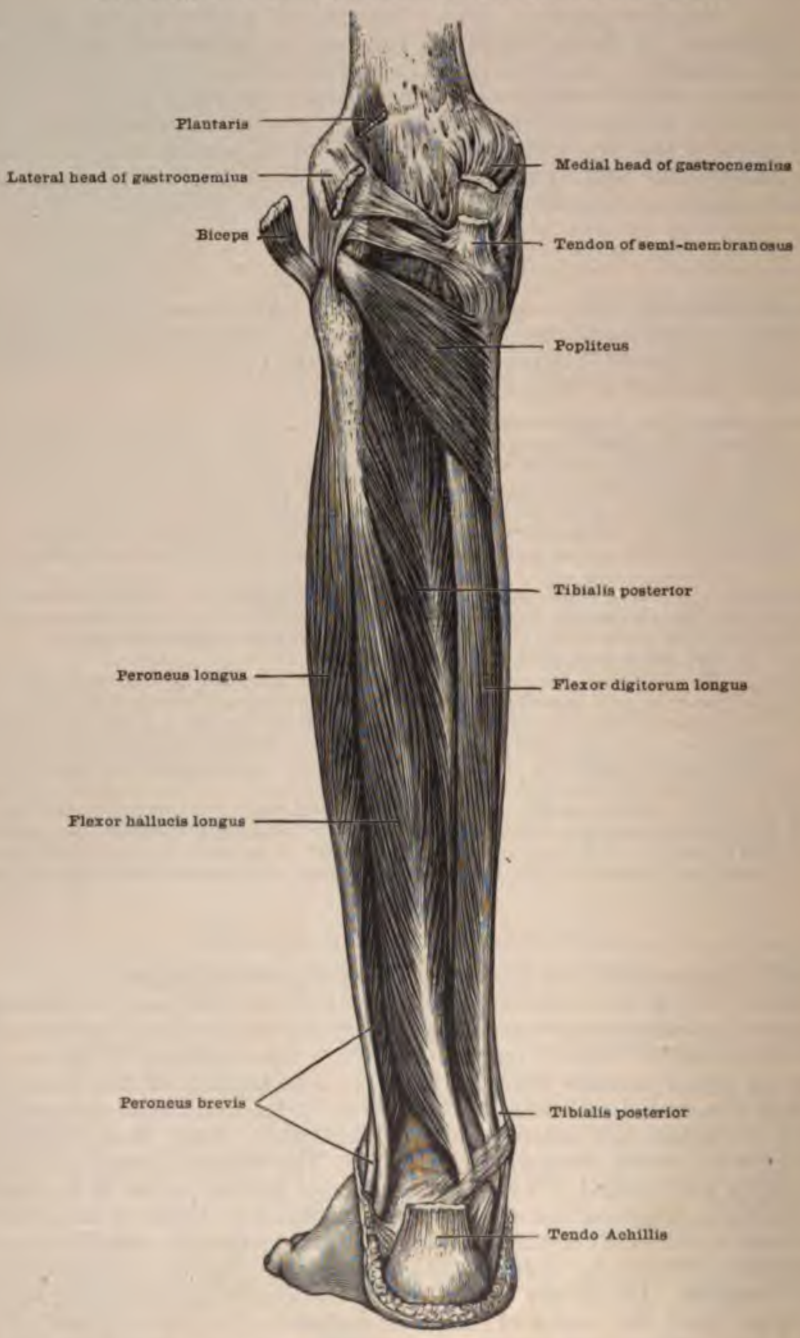
Cruro-pedal Muscles (figs. 364, 367)

Of the three muscles of this group, the **flexor digitorum longus** lies on the tibial side of the leg, the **flexor hallucis longus** on the fibular side, and the **tibialis posterior** upon the interosseous membrane, partly covered by the other two muscles, beneath the former of which it crosses, distally, to the tibial side of the leg. Septa separate the flexor muscles from the tibialis. The tendons of the three muscles pass behind the medial malleolus, held in place by the transverse septum and the deep layer of the laciniate (internal annular) ligament. They lie in compartments divided by septa which descend to the tibia. The compartment for the tibialis posterior is the most medial. It is partly overlapped by that for the flexor digitorum. At the ankle the tendon of the tibialis passes above, the tendon of the flexor digitorum medial to, and that of the flexor hallucis below, the sustentaculum tali, each in a separate osteo-fibrous canal bounded externally by the laciniate (internal annular) ligament. In the sole the tendon of the long flexor of the big toe passes under (deeper than) the tendon of the flexor digitorum, to which it gives a slip, and is inserted into the terminal phalanx of the big toe. The tendon of the long flexor of the toes passes obliquely across the sole, is joined by the quadratus plantæ (flexor accessorius), and gives rise to a tendon for the terminal phalanx of each of the four lateral toes. From these tendons the lumbrical muscles arise. The tibialis posterior has an extensive insertion on the plantar surface of the tarsus.

The long flexors act chiefly on the toes. Together with the tibialis posterio they invert and extend the foot.

The long flexor of the toes probably represents the flexor profundus and the flexor pollici longus of the forearm. The tendons of the deep flexors of the forearm do not, however, cros like those of the long flexors of the toes. In the lower mammals there is much variation in t toes to which the tibial and fibular flexors are distributed. The tibialis posterior has no c tain representative in the forearm. The rare ulno-carpeus may represent it.

Fig. 364.—The Deep Muscles of the Back of the Leg.


Plantaris
Lateral head of gastrocnemius
Biceps
Medial head of gastrocnemius
Tendon of semi-membranosus
Popliteus
Tibialis posterior
Peroneus longus
Flexor digitorum longus
Flexor hallucis longus
Peroneus brevis
Tibialis posterior
Tendo Achillis

The flexor digitorum longus (figs. 364, 367).—*Origin.*—From the popliteal line, the medi side of the second quarter of the dorsal surface of the tibia, the fibrous septum between the muscle and the tibialis posterior, and the fascia covering its proximal extremity.

Structure and Insertion.—From these areas of origin the fibre-bundles run obliquely to be inserted in a penniform manner on a tendon which begins in the proximal quarter of the muscle as a narrow septum, and more distally becomes a strong band on the medial margin. The insertion of the fibre-bundles continues nearly to the medial malleolus. From here the tendon passes behind the medial malleolus, dorso-lateral to the tendon of the tibialis posterior, crosses the posterior talo-tibial ligament, and passes along the medial margin of the sustentaculum tali into the sole of the foot. Here it crosses the tendon of the flexor hallucis longus, from which it receives a tendinous slip, and divides into four parts, which pass to the second to the fifth toes. Each tendon is bound to the phalanges of the toe to which it passes by a fibrous sheath. Superficial to it in the sheath lies a tendon of the flexor digitorum brevis, which the flexor longus tendon perforates as it passes to the base of the terminal phalanx. The tendon is connected, like those of the fingers, by vincula tendinum, to the phalanges of the toes.

Nerve-supply.—From the tibial (posterior tibial) nerve a branch arises, often in company with nerves to some other or others of the muscles of this group. The nerve divides into two branches, one of which passes to the lateral side of the muscle, where it extends along near the middle of the fibre-bundles of that side, while the other branch passes along near the middle of the fibre-bundles of the medial side of the muscle.

Relations.—In the proximal half of the leg it lies on the tibia, in the distal half on the posterior tibial muscle. Between it and the flexor hallucis lie the posterior tibial vessels and nerve. Near the ankle the plantar vessels and nerves cross the tendon of the muscle, separated from it by the deep layer of the laciniate (internal annular) ligament. In the upper two-thirds of its extent it is covered by the triceps suræ. In the lower third of the leg it emerges medial to the soleus and the tendon of Achilles. The relations of its tendon at the ankle have been described above. The tendon lies beneath the origin of the abductor hallucis muscle and in the sole is covered by the flexor digitorum brevis, crosses the tendon of the long flexor and the oblique adductor of the big toe and the interosseous muscles, is joined by the quadratus plantæ (flexor accessorius), and gives origin to the lumbrical muscles.

The flexor hallucis longus (figs. 364, 367).—*Origin.*—From the distal two-thirds of the posterior surface of the fibula, the septa between it and the tibialis posterior and peroneal muscles, and the fascia above its proximal extremity.

Structure and Insertion.—The fibre-bundles converge upon a tendon which begins in the second quarter of the muscle, within its substance, and emerges upon the postero-medial margin in its distal half. The insertion of the fibre-bundles continues to the end of the tibia. From here the tendon passes over the dorsal talo-tibial (tibio-astragaloid) ligament, and through the groove on the under surface of the lateral process of the talus and the sustentaculum tali, where it lies on the fibular side of the tendon of the flexor digitorum longus. It then crosses the deep surface of this tendon, to which it gives a slip, passes over the plantar surface of the medial head of the flexor hallucis brevis, and between the sesamoid bones of this muscle into the osteo-fibrous canal on the plantar surface of the big toe. It is inserted into the base of the terminal phalanx of the big toe.

Nerve-supply.—The nerve arises from the tibial (posterior tibial) nerve, often in company with the nerve to the flexor digitorum longus or the other muscles of the group. It runs along the deep surface of the muscle and sends twigs into the middle third of its constituent fibre-bundles. Sometimes two nerves are furnished to the muscle.

Relations.—It lies on the fibular side of the distal two-thirds of the leg. Proximally it diverges from the preceding muscle so as to disclose the tibialis posterior, which is more deeply situated. Between it and the tibialis posterior lie the peroneal vessels. Distally its tibial margin approaches the flexor digitorum longus, but between them lie the posterior tibial vessels and nerve. Lateral to it lie the peroneal muscles. It is covered in the leg by the soleus. In the distal part of the leg its tendon lies medial to the tendon of Achilles. On entering the foot the tendon crosses beneath the abductor hallucis muscle and the lateral plantar vessels and nerve. The other relations of the tendon have been described above.

The tibialis posterior (figs. 364, 369).—*Origin.*—From—(1) the lateral half of the distal margin of the popliteal line and the middle third of the posterior surface of the tibia; (2) the medial side of the head and of that part of the body of the fibula next the interosseous membrane in the proximal two-thirds; (3) from the whole of the proximal and the lateral portion of the distal part of the posterior surface of the interosseous membrane; and (4) from the septa between its proximal portion and the long flexor muscles.

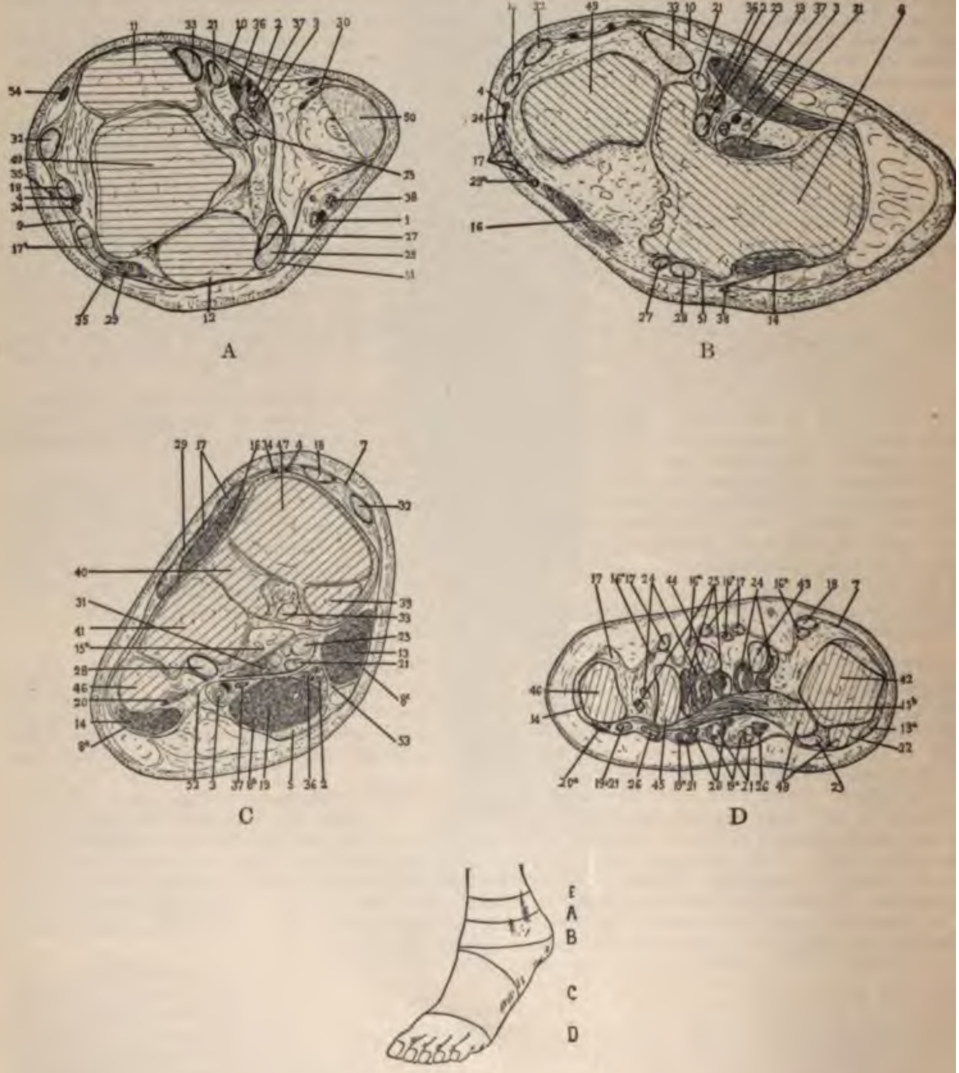
Structure.—From this extensive area of origin the fibre-bundles converge upon a tendon which is at first deep seated within the muscle-belly, but about the middle of the leg emerges on the medial margin of the muscle. The fibular portion of the muscle is much more extensive than the tibial. The proximal fibres take a nearly perpendicular, the most distal (from the fibula) a nearly transverse, course. The insertion of fibres stops a little proximal to the medial malleolus. The tendon then extends to the medial side of the tendon of the long flexor of the toes, passes through the groove on the back of the malleolus, across the medial talo-tibial (tibio-astragaloid) ligament, and above the sustentaculum tali to the sole.

Insertion.—The tendon divides into two chief divisions, a deep and a superficial. (1) The deep portion becomes attached chiefly to the tubercle of the navicular bone, and usually in part also to the first cuneiform. (2) The superficial spreads out to be attached chiefly to the third cuneiform and the base of the fourth metatarsal, but also in part to the second cuneiform, to the capsule of the naviculo-cuneiform joint, to the sulcus of the cuboid, and usually also to the origin of the short flexor of the big toe and the base of the second metatarsal. Slips may, however, also be given to other structures. A sesamoid bone is usually found in the tendon either near the calcaneo-navicular ligament or the navicular bone.

FIG. 365, A–D.—TRANSVERSE SECTIONS THROUGH THE FOOT IN THE REGIONS SHOWN IN TH
DIAGRAM.

/ in the diagram indicates the region through which passes section F, fig. 361 (p. 450).

1. Peroneal artery. 2. Medial plantar artery. 3. Lateral plantar artery. 4. Anterior tibia artery. 5. Plantar aponeurosis. 6. Calcaneus. 7. Dorsal pedal fascia. 8. Planta fascia—a, lateral; b, intermediate; c, medial. 9. Cruciate (anterior annular) ligament 10. Laciniate (internal annular) ligament. 11. Lateral malleolus. 12. Medial malleolus 13. Abductor hallucis—a, tendon. 14. Abductor quinti digiti—a, insertion. 15. Adducto hallucis—a, oblique head, origin; b, transverse head. 16. Extensor digitorum brevis—a, tendons. 17. Extensor digitorum longus, tendons. 18. Extensor hallucis longus, tendon 19. Flexor digitorum brevis—a, tendon. 20. Flexor digiti quinti brevis—a, tendon 21. Flexor digitorum longus, tendon. 22. Flexor hallucis brevis tendon. 23. Flexo hallucis longus. 24. Interossei dorsales. 25. Interossei plantares. 26. Lumbricales. 27 Peroneus brevis. 28. Peroneus longus. 29. Peroneus tertius—a, tendon. 30. Plantaris tendon. 31. Quadratus plantæ. 32. Tibialis anterior, tendon. 33. Tibialis posterior, tendon. 34. Deep peroneal nerve. 35. Superficial peroneal nerve. 36. Medial planta nerve. 37. Lateral plantar nerve. 38. Sural (external saphenous) nerve. 39. Cuneiform I 40. Cuneiform III. 41. Cuboid. 42. Metacarpal I. 43. Metacarpal II. 44. Metacarpal III. 45. Metacarpal IV. 46. Metacarpal V. 47. Navicular. 48. Sesamoid bones 49. Talus (astragalus). 50. Tendo Achillis. 51. Retinacula mm. peroneorum. 52. Lateral intermuscular septum. 53. Medial intermuscular septum. 54. Great saphenous vein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D

Nerve-supply.—The nerve arises from the tibial (posterior tibial) in company often with branches to the other muscles of the group. It enters the posterior surface of the muscle in its proximal third, and gives off one or two branches for the tibial fasciculus. The main trunk descends across the middle third of the fasciculi arising from the fibula.

Relations.—The muscle covers the posterior surface of the interosseous membrane, and extends distally over the posterior surface of the tibia beneath the flexor digitorum longus. It is covered proximally by the soleus, distally by the two long digital flexors. The posterior tibial and peroneal arteries and the tibial (posterior tibial) nerve run upon its posterior surface. The tendon in the sole is under cover of the origin of the plantar muscles of the big toe.

Action.—The tibialis posterior adducts the foot and slightly inverts it. The flexor digitorum longus flexes the terminal phalanx on the second and the second on the first, and at the height of its contraction the first on the metatarsals. It also rotates medially to some extent the ends of the fourth and fifth toes, and inverts the foot. The flexor hallucis longus flexes the second phalanx of the big toe on the first, and, less energetically, the first on the metatarsal. It also inverts the foot. All three muscles serve to extend the foot. The flexor hallucis is the strongest of the three in this respect.

Variations.—The muscles of the group may be more or less fused with one another or be united by fasciculi. This is especially common between the two flexors of the toes. The individual muscles vary in development. The flexor digitorum longus may be more or less divided into separate fasciculi for the individual toes. The slip from the flexor hallucis longus to the flexor digitorum longus varies greatly in extent, but usually passes mainly to the second and third toes, more rarely to the second, third, and fourth, and very rarely to the fifth. In most of the apes the tibial flexor (flexor digitorum) sends tendons to the second and fifth, the fibular flexor (flexor hallucis) to the first, third, and fourth toes. This condition is also sometimes found in man. A slip may pass from the tendon of the flexor digitorum to that of the flexor hallucis longus. There may be a sesamoid bone in the tendon of the flexor hallucis longus as it passes over the talus (astragalus) and calcaneus. The tibialis posterior may be doubled. Aberrent fasciculi may arise from various regions on the back of the leg and join any one of the three muscles of the group.

ABNORMAL MUSCLES

The soleus accessorius.—Arises by a tendon from the head of the fibula beneath the soleus. Slender belly, 8 cm. long. Passes through the tibial nerve and is inserted into the medial surface of calcaneus.

The tibialis secundus (tensor of capsule of ankle-joint).—A small muscle which arises from the tibia beneath the flexor digitorum and is inserted into the capsule of the ankle-joint.

The fibulo-calcaneus medialis (peroneo-calcaneus internus of MacAlister, flexor accessorius long. dig. long., etc.).—A fasciculus which arises from the lower third of the body of the fibula and gives rise to a tendon which passes beneath the laciniate ligament to the quadratus plantæ or to the tendon of the flexor digitorum longus.

BURSÆ

B. subtendinea m. tibialis posterioris.—A small bursa between the navicular fibrocartilage and the tendon.

SYNOVIAL TENDON-SHEATHS

Vagina m. flexoris digitorum longi.—The tendon is surrounded by a synovial sheath from the back of the medial malleolus to where it crosses the tendon of the flexor hallucis longus below the navicular bone. It may communicate with the sheath of the tibialis anterior or with that of the flexor hallucis longus. **Vaginæ tendinum digitales.**—The tendons of the long flexor, together with those of the short flexor, are surrounded by synovial sheaths from the heads of the metatarsals to the insertions of the tendons. In structure these resemble those of the fingers. **Vagina m. flexoris hallucis longi.**—The tendon is surrounded by a sheath from the back of the medial malleolus to the crossing of the tendon of the flexor digitorum longus. Another sheath surrounds the tendon from the middle of the first metatarsal to its insertion. **Vagina m. tibialis posterioris.**—The tendon is surrounded by a synovial sheath extending from a region proximal to the medial malleolus to the insertion of the tendon.

5. MUSCLES OF THE SOLE OF THE FOOT

These muscles will be taken up in the following order:—(*a*) the flexor digitorum brevis; (*b*) the muscles associated with the tendons of the flexor digitorum longus; (*c*) the intrinsic muscles of the great toe; (*d*) the intrinsic muscles of the little toe; and (*e*) the interosseous muscles.

a. FLEXOR DIGITORUM BREVIS (fig. 366)

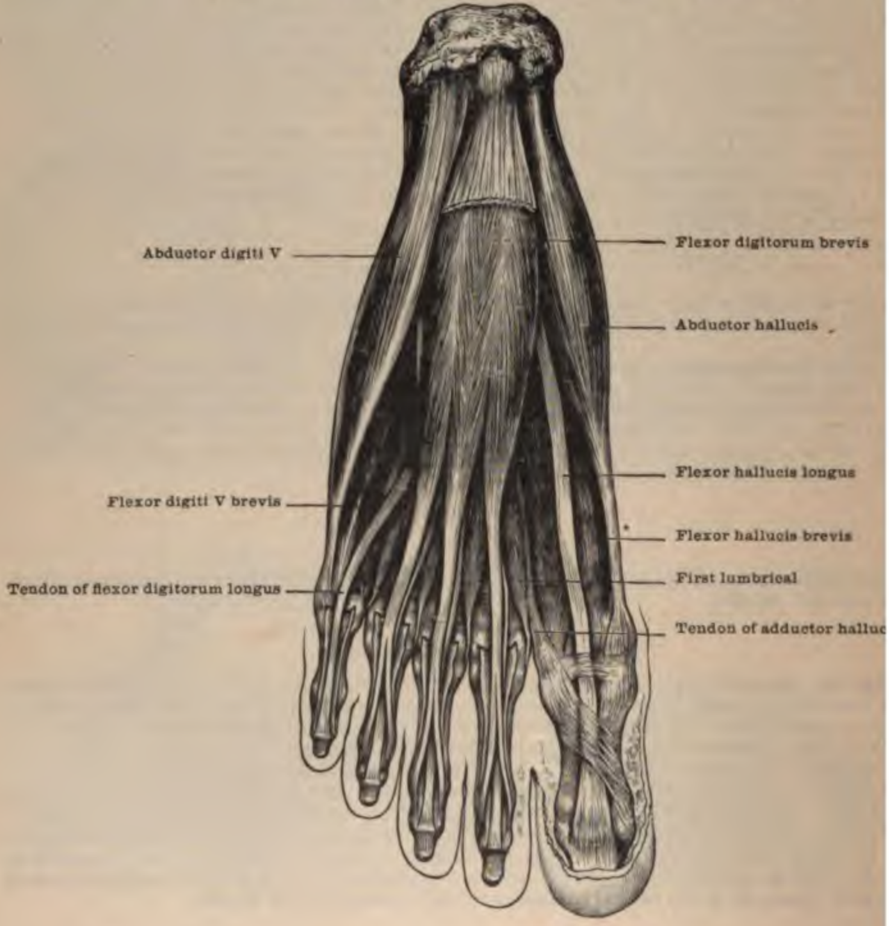
The **flexor digitorum brevis,** the most superficially placed of the plantar muscles, lies in the mid-plantar region beneath the plantar fascia and over the tendons of

the long flexor of the toes and its associated muscles. It has a flat, elongatec
which towards the middle of the sole is prolonged into four processes, each o
has a special tendon that becomes attached to the second phalanx of one of t
lateral toes. The tendons of the muscle correspond to those of the flexor s
in the palm. The belly of the flexor sublimis is supposed to be represented
soleus.

Origin.—From (1) the medial process of the tuber calcanei; (2) the posterior thirc
plantar aponeurosis; and (3) the medial and lateral intermuscular septa.

Structure.—The constituent fibre-bundles pass distally in a compact mass. The
of insertion begin within the muscle substance, and as the fibre-bundles become ins
them, the separate fasciculi become more and more distinct. The fasciculi for the sec
third toes are larger and arise more superficially than those for the fourth and fifth toe

FIG. 366.—FIRST LAYER OF THE MUSCLES OF THE SOLE



fasciculus for the fifth toe is often very small, and its tendon takes an oblique course to
sertion.

Insertion.—The tendons of the short flexor pass superficial to those of the long fle
the osteo-fibrous canals on the flexor surface of the digits. Upon the first phalanx of
the tendon of the short flexor divides and forms an opening (chiasma tendinis) throug
the tendon of the long flexor passes, while the tendon of the short flexor becomes attache
base of the second phalanx. The arrangement is essentially like that described at lengt
flexors of the fingers (p. 390).

Nerve-supply.—From the medial plantar nerve by a branch which enters the midd
of the deep surface near the medial margin of the muscle.

Action.—It is a strong flexor of the second row of phalanges.

Relations.—The short flexor is separated from the abductors of the big toe and li
by strong intermuscular septa (p. 453), and from the long flexor tendons and the qu
plantæ (flexor accessorius) by a transverse septum in which the lateral plantar vess

nerve cross the foot. In its distal two-thirds it is separated from the plantar fascia by loose tissue.

Variations.—The muscle shows a tendency towards reduction, one or more of its fasciculi being frequently absent, and occasionally the whole muscle. The fasciculus for the fifth toe is absent in about 20 per cent. of bodies (Le Double). When a fasciculus is absent, its tendon is usually replaced by an accessory tendon from the long flexor. The muscle or its tendons may be more or less fused to the tendons of the flexor digitorum longus.

b. MUSCLES ATTACHED TO THE TENDONS OF THE FLEXOR DIGITORUM LONGUS (fig. 367)

The muscles belonging in this group are the **quadratus plantæ** (flexor accessorius), a flat, quadrangular, bicipital muscle which runs from the medial and plantar surface of the body of the calcaneus to the dorso-lateral margin and deep surface of the long flexor tendon; and the **lumbricales,** four slender bipinnate muscles which run from the medial sides of the digital slips of the tendon to the medial sides of the four more lateral toes. The quadratus aids the long flexor muscle; the lumbricales serve to extend the last two phalanges and to flex the first phalanx of each of the digits to which they pass. The lumbrical muscles correspond to those of the hand. The quadratus is not there represented.

The quadratus plantæ (flexor accessorius) (fig. 367).—This muscle *arises* by two heads. The *lateral head* springs by an elongated tendon from the calcaneus in front of the lateral process of the tuber, and from the lateral margin of the long plantar ligament. The *medial head* arises directly from the medial surface of the body of the calcaneus as far back as the medial process of the tuber calcanei, and from neighbouring ligaments.

Structure and Insertion.—The two heads are separated at their origin by a short triangular space. They soon fuse to form a single belly, but the fibre-bundles of each head in the main are separately inserted. Those from the lateral head diverge to be attached to the lateral margin of the flexor tendon. Those from the medial head are inserted on a tendon that begins on the medial margin and deep surface of this head, becomes broader, and is inserted as a flat aponeurosis on the deep surface of the flexor tendon. There are great individual variations in the structure of this muscle. The fibres of either part may be inserted with those of the other part.

Nerve-supply.—From a branch of the lateral plantar nerve which passes obliquely across the superficial surface of the muscle parallel with the tendon of the flexor digitorum longus.

Relations.—The muscle lies in a fascial compartment with the long flexor tendons. This compartment is bounded on each side by intermuscular septa, deeply by the tarsus, and plantarwards by a septum which intervenes between it and the flexor digitorum brevis, and in which the lateral plantar nerve and vessels cross to the lateral side of the foot.

Action.—It assists the long flexor tendon in flexing the toes. It serves to make the direction of traction on the toes parallel with the long axis of the foot.

Variations.—It is frequently reduced in size. The lateral head is not infrequently missing, the medial head or the whole muscle much more rarely. The mode of attachment to the tendon varies. It may be inserted in part or wholly into the long flexor of the great toe. It may receive, in about one body in twenty (Wood), an accessory slip of origin from the fibula, one of the muscles of the leg, the fascia of the leg or foot, or the medial surface of the calcaneus, etc.

The lumbricales.—The three lateral muscles *arise* from the contiguous sides of the digital tendon-slips of the flexor digitorum longus in the angles of division. The first lumbrical arises on the medial margin of the tendon to the second toe. The fibre-bundles of each muscle converge on both sides of a tendon which becomes free near the metatarso-phalangeal joint and is *attached* to the medial side of the first phalanx of the toe to which the muscle belongs. A tendinous expansion is sent into the aponeurosis of the extensor muscle.

Nerve-supply.—The three lateral lumbrical muscles are most frequently supplied by branches of the deep ramus of the lateral plantar nerve, the medial by the first common plantar digital branch of the medial plantar nerve. The latter nerve may supply the two more medial muscles or the more medial muscles may receive a double supply. The branches of the lateral plantar nerve enter the deep surfaces of the muscles in the middle third. The branches of the medial plantar enter the medial borders of the muscles near the junction of the proximal and middle thirds.

Relations.—The lumbrical muscles lie in a plane with the long flexor tendons deeper than the flexor brevis tendons and superficial to the adductor hallucis. The deep branches of the lateral plantar nerve and vessels pass across their deep surface; superficial branches of both plantar nerves across the superficial surface.

Action.—To extend the last two phalanges of the toes and to flex the first.

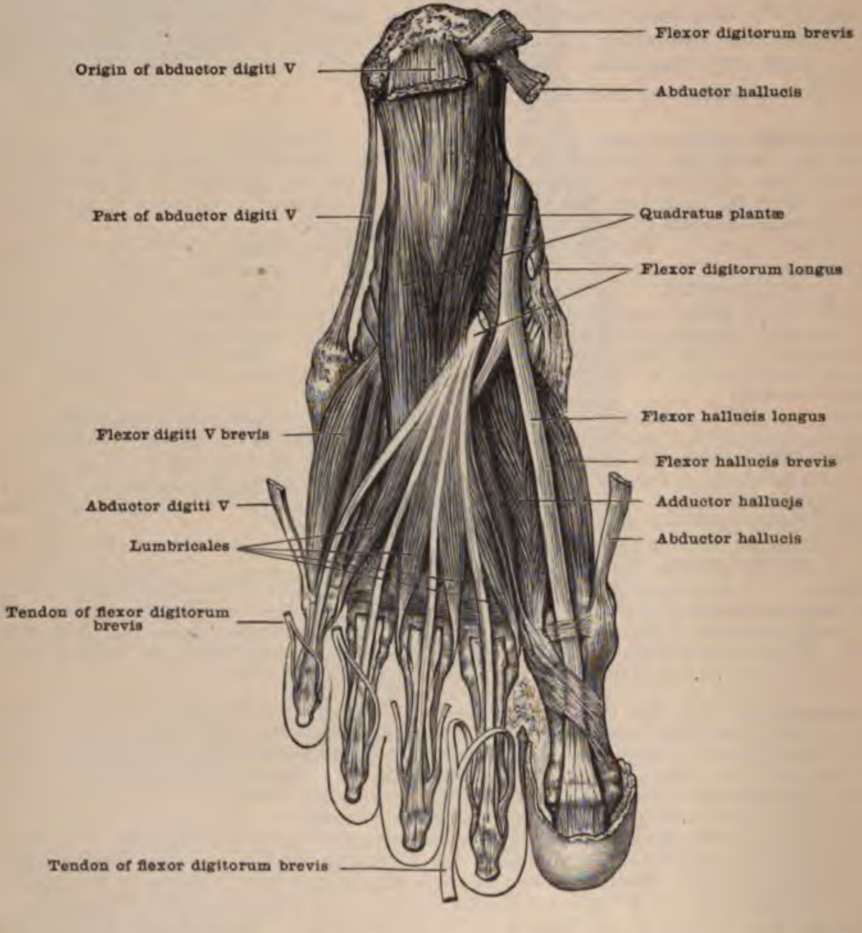
Variations.—One or more of the muscles may be absent. Sometimes a muscle is doubled. This is more frequently the case with the third and fourth muscles. The first may arise wholly from the tendon of the posterior tibial muscle or from this and the long flexor of the big toe. The third lumbrical may arise from the flexor digitorum brevis. The second and fourth lumbricals may be inserted into the tendons of the flexor digitorum brevis.

c. Intrinsic Muscles of the Great Toe (figs. 366–368)

These muscles are the abductor, flexor brevis, and adductor. Of the three muscles, the first two lie in the medial fascial compartment, while the last lies in the middle compartment covered by the flexor digitorum longus and its associated muscles.

The **abductor hallucis** (fig. 366), the largest and most superficial of these muscles, lies on the bordet of the sole medial to the short flexor muscle. It passes from the calcaneus across the tendons of the long flexor muscles, and is inserted into the medial side of the base of the first phalanx of the great toe and into the medial side of the long extensor tendon. It is partly fused to the medial belly of the flexor hallucis brevis. The **flexor hallucis brevis** (fig. 368) is a bicaudal muscle which lies over the first metatarsal. It arises in the region of the cuneiform bones and is inserted on each side of the base of the first phalanx. Between its two bellies and insertio runs the tendon of the long flexor of the great toe. Proximally and medially the flex brevis is crossed by the abductor hallucis. Its lateral belly and tendon are part fused with the oblique head of the adductor. The **adductor hallucis** (fig. 368) composed of two distinct heads, an oblique and a transverse. The oblique head e tends from the long plantar ligament under cover of the tendons of the flexor digitoru longus and the lumbrical muscles to the lateral side of the base of the first phalan of the great toe. Its tendon of insertion is joined by the transverse head, which e tends from the capsules of the third to the fifth metatarso-phalangeal joint Beneath the adductor lie the more medial interosseous muscles.

Fig. 367.—Second Layer of the Muscles of the Sole.

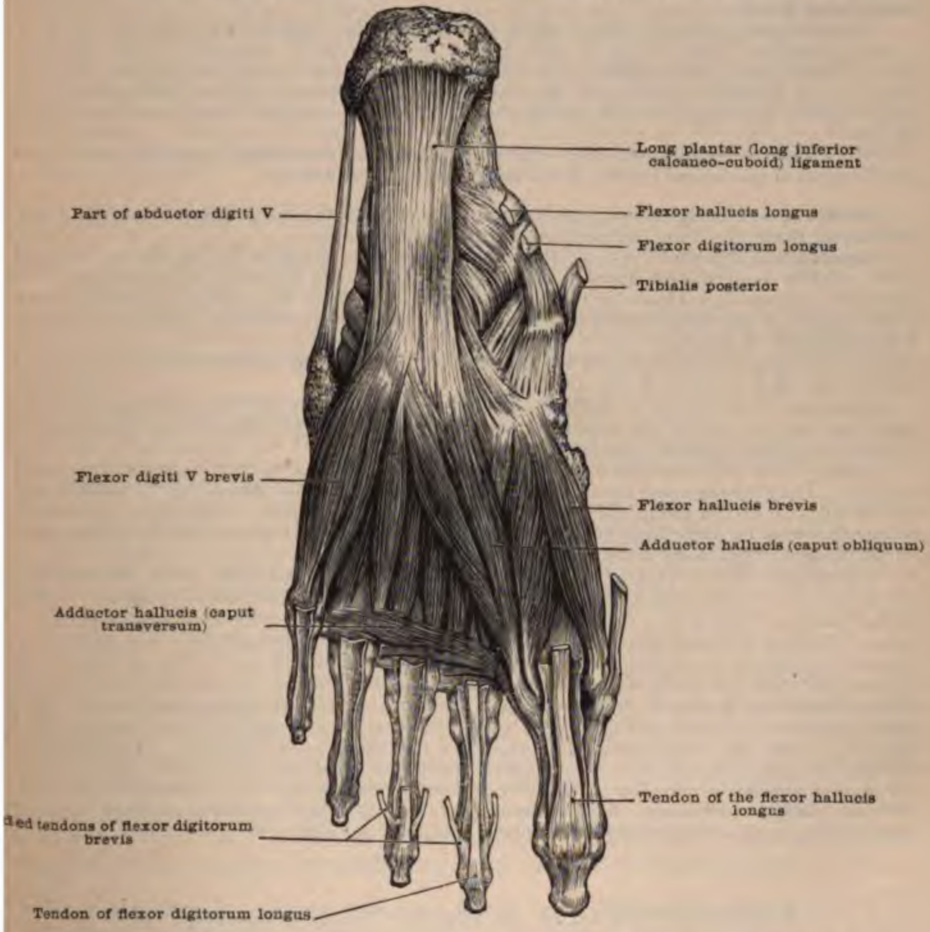

Flexor digitorum brevis
Origin of abductor digiti V
Abductor hallucis
Part of abductor digiti V
Quadratus plantæ
Flexor digitorum longus
Flexor hallucis longus
Flexor digiti V brevis
Flexor hallucis brevis
Abductor digiti V
Adductor hallucis
Abductor hallucis
Lumbricales
Tendon of flexor digitorum brevis
Tendon of flexor digitorum brevis

These muscles perform not only the functions indicated by their names, but als nd the second phalanx. They correspond fairly well with those of the thumb. opponens is not normally present in the foot.

The abductor hallucis (fig. 366).—*Origin.*—From (1) the medial process of the tuber nei; (2) the deep surface of the neighbouring plantar fascia; (3) the laciniate (internal lar) ligament; (4) the septum between the muscle and the flexor digitorum brevis; and fibrous arch which extends on the deep surface of the muscle over the plantar vessels and es and the long flexor tendons from the calcaneus to the navicular bone.

Structure.—From the medial process of the tuber calcanei a tendinous band passes to the , lateral side of the muscle. Numerous tendinous bands arise from the other areas of n. The fibre-bundles arise from these tendons and directly from the fibrous arch. They ttached in a penniform manner to numerous tendinous slips which extend far up in the cle. These slips become gradually fused into a tendon which appears on the superficial tar aspect of the muscle. Opposite the distal half of the first metatarsal bone the tendon

FIG. 368.—THIRD LAYER OF THE MUSCLES OF THE SOLE.


Long plantar (long inferior calcaneo-cuboid) ligament
Part of abductor digiti V
Flexor hallucis longus
Flexor digitorum longus
Tibialis posterior
Flexor digiti V brevis
Flexor hallucis brevis
Adductor hallucis (caput obliquum)
Adductor hallucis (caput transversum)
Tendon of the flexor hallucis longus
ed tendons of flexor digitorum brevis
Tendon of flexor digitorum longus

es the belly of the muscle and becomes closely bound to the medial belly of the flexor hallu- revis.

Insertion.—In conjunction with the tendon of the medial belly of the flexor brevis into the of the first phalanx. It usually sends an expansion to the extensor tendon.

Nerve-supply.—A branch from the medial plantar nerve usually enters near the middle e lateral border of the muscle.

Relations.—It is covered by the plantar fascia and is separated from the muscles of the ian compartment by the medial intermuscular septum. It crosses the tendons of the tibialis rior, tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles and the tar vessels and nerves.

The flexor hallucis brevis (fig. 368).—*Origin.*—From a tendon attached to the first (in- al) and second (middle) cuneiform bones. The more lateral of its fibres are continued into lantar calcaneo-cuboid ligament and the more medial into the expansion of the tendon of the erior tibial muscle.

Structure and Insertion.—The fibre-bundles give rise to two bellies, a medial and a lateral. Those of the medial belly pass obliquely medially to be inserted into the tendon of the abductor hallucis, and by a short tendon fused with this into the medial side of the plantar surface of the base of the first phalanx. This tendon contains a sesamoid bone. Those of the lateral converge upon the tendon of the oblique head of the adductor, and the two muscles are inserted by a common tendon, which contains a sesamoid bone, into the lateral side of the plantar surface of the base of the first phalanx.

Nerve-supply.—A branch from the medial plantar nerve divides over the plantar surface of the muscle and gives a twig to each belly near the middle third. Rarely the lateral belly may receive a branch from the lateral plantar nerve.

Relations.—The abductor hallucis covers it medially; the tendon of the flexor hallucis longus passes between its two heads. Branches of the medial plantar vessels and nerve lie on its superficial surface.

The adductor hallucis (fig. 368).—The **Oblique Head.**—*Origin.*—From (1) the tuberosity of the cuboid and the sheath over the tendon of the peroneus longus muscle; (2) the plantar calcaneo-cuboid ligament; (3) the third cuneiform; (4) the bases of the second and third metatarsals and (5) a fibrous arch which extends from the plantar calcaneo-cuboid ligament to the interosseous fascia.

Structure and Insertion.—From short tendon-slips the fibre-bundles pass forwards to form a thick, fusiform belly which is attached in a bipenniform manner to a flat tendon. The tendon begins about the middle of the plantar surface of the muscle and is inserted in common with that of the flexor brevis into the lateral side of the plantar surface of the base of the first phalanx, and by a slip into the aponeurosis of the long extensor muscle on the back of the big toe.

Nerve-supply.—A branch from the deep ramus of the lateral plantar nerve enters the middle third of the lateral border of the muscle on its deep surface.

The **transverse head** *arises* from the joint-capsules of the third, fourth, and fifth metatarsophalangeal joints and from the transverse capitular ligaments.

Structure and Insertion.—Of the three fasciculi, that to the little toe lies nearest the heel, that to the middle toe the most distally. The fibre-bundles take a nearly parallel course to be attached to tendon-slips which are fused into a common tendon that splits and passes on each side of the tendon of the oblique head and is inserted into the sheath of the tendon of the long flexor of the great toe (Leboucq).

Nerve-supply.—A branch from the deep ramus of the lateral plantar nerve enters the middle third of the deep surface of the muscle.

Relations.—The adductor hallucis is crossed superficially by the tendons of the flexor digitorum longus and by the lumbrical muscles. On its deep surface lie the interosseous muscles, and the deep plantar vessels and nerves.

Action.—The actions of the muscles of this group are indicated by the names of the individual muscles. The abductor and the oblique head of the adductor are also flexors of the first phalanx. All the muscles of the group aid in extending the second phalanx. The transverse head of the adductor serves to draw together the heads of the metatarsals after they have been separated by the weight of the body during the tread.

Variations.—The extent of fusion of the abductor and adductor with the two heads of the short flexor varies considerably. The abductor may receive an accessory fasciculus from the medial border of the foot. Either the adductor or the flexor brevis may send a tendon to the base of the first phalanx or to the short flexor tendon of the second toe. The adductor shows frequent variations in relation to its metatarsal attachments, owing to the fact that originally a fasciculus from the body of the second (and third) metatarsal was probably normally present and the transverse head was more developed (Leboucq). The **opponens hallucis** is a fasciculus occasionally found which extends from the short flexor or the medial intermuscular septum to the body of the first metatarsal. This muscle is normal in some monkeys. An **adductor digiti secundi** has been seen to arise from various sources and become attached to the lateral side of the plantar surface of the base of the first phalanx of the second toe. This muscle may be fused with the oblique adductor. A corresponding muscle is found normally in some apes, and in some of the lower animals there is a special adductor for each toe.

d. INTRINSIC MUSCLES OF THE LITTLE TOE (figs. 366–368)

In this group belong three muscles, an abductor, a flexor and an opponens. The largest of these, the **abductor digiti quinti** (fig. 366), extends superficially over the lateral margin of the foot from the lateral side of the tuber calcanei to the base of the little toe. The **flexor digiti quinti brevis** (fig. 368) is a small, flat muscle which lies on the plantar surface of the fifth metatarsal. The **opponens** is a small muscle lying lateral to this. The two, which are often fused, arise from the cuboid. The flexor brevis is attached to the plantar side of the base of the first phalanx of the little toe. The opponens is attached to the lateral surface of the metatarsal. The abductor corresponds with the abductor of the little finger. The opponens and flexor brevis correspond probably with the deep part of the opponens of the little finger.

The abductor digiti quinti (fig. 366).—*Origin.*—From (1) the lateral process of the tuber calcanei and the lateral and plantar surface of the body of the bone in front of this; (2) the lateral intermuscular septum; (3) the deep surface of the lateral plantar fascia, including the fibrous band extending from the calcaneus to the lateral side of the base of the fifth metatarsal bone.

Structure.—The fibre-bundles run obliquely to a flat tendon of insertion. This begins within the muscle near the calcaneo-cuboid joint, soon emerges on the medial side of the deep surface, and becomes free near the metatarso-phalangeal joint. Considerable individual variation in structure is found.

Insertion.—On the lateral surface of the first phalanx of the little toe and the metatarso-phalangeal capsule. Often a slip is sent to the extensor tendon. While usually the muscle glides over the tuberosity of the fifth metatarsal, it frequently sends a second fasciculus to be attached to this bone (**abductor ossis metatarsi quinti**). A special fasciculus from the tuberosity often constitutes the lateral margin of the muscle.

Nerve-supply.—The nerve arises from the lateral plantar. In may be distributed either near the deep or the superficial surface of the muscle. The former appears to be the case when the muscle is slightly developed. The chief intramuscular branches then extend across the middle third of the constituent fibre-bundles near the deep surface. In case the calcaneo-metatarsal bundles are well developed, the nerve enters the proximal margin of the muscle and its chief branches extend across the middle third of the more superficial muscle-bundles, finally terminating in the distal margin of the muscle.

Relations.—It is ensheathed by the plantar fascia and the lateral intermuscular septum. It lies superficial to the quadratus plantæ (flexor accessorius), the opponens and flexor brevis of the little toe. the long plantar ligament, and the tendon of the peroneus longus muscle.

The flexor digiti quinti brevis (fig. 368).—*Origin.*—From the sheath of the peroneus longus, the tuberosity of the cuboid, and (3) the base of the fifth metatarsal.

Structure and Insertion.—The fibre-bundles take a nearly parallel course, although the belly is slightly fusiform. They are attached by short tendinous bands to the base of the first phalanx of the little toe, the capsule of the corresponding joint, and the aponeurosis on the dorsal surface of the toe.

Nerve-supply.—A branch of the superficial ramus of the lateral plantar nerve sends twigs to the middle third of the plantar surface of this and the following muscle.

Relations.—It is covered medially by the plantar fascia, laterally by the abductor of the fifth toe. Medially it lies superficial to the third plantar interosseous muscle.

The opponens digiti quinti.—This muscle *arises* from the sheath of the peroneus longus and the tuberosity of the cuboid by a slender tendon which passes over the tuberosity of the fifth metatarsal and gives rise to fibre-bundles which are *inserted* on the lateral surface of the fifth metatarsal.

Nerve-supply.—From branches of the nerve to the flexor brevis.

Relations.—It is covered by the abductor of the fifth toe.

Actions.—The abductor and flexor brevis abduct the little toe and flex the first phalanx. They act as extensors of the second and third phalanges. The opponens serves to draw the little toe medially in a plantar direction.

Variations.—The muscles of this group may be more or less completely fused. The abductor, in addition to the variations mentioned above may send tendons to the third and fourth metatarsals. The opponens is frequently missing. The **abductor accessorius digiti quinti** is a rare muscle which arises from the lateral process of the tuber of the calcaneus and is inserted into the lateral surface of the base of the first phalanx of the little toe.

e. THE INTEROSSEOUS MUSCLES (fig. 369)

Two groups of interosseous muscles are recognised, a dorsal and a plantar. The dorsal are the larger and fill the interspaces. The first two are attached to each side of the base of the first phalanx of the second toe; the third and fourth on the lateral sides of the bases of the first phalanges of the third and fourth toes. The plantar interossei lie on the medial side of the ventral surfaces of the third, fourth, and fifth metatarsals, and are attached each on the medial side of the base of the first phalanx of the corresponding toe. In the hand the axis about which the interosseous muscles are arranged passes through the middle finger, in the foot through the second toe.

The interossei dorsales.—Each of the three lateral dorsal interosseous muscles *arises* from—(1) the sides of the shaft and the plantar surface of the bases of the metatarsal bones bounding the space in which it lies; (2) from the fascia covering it dorsally; and (3) from fibrous prolongations from the long plantar ligament. The first has a similar origin except that it is attached medially to the base of the first metatarsal and to a fibrous arch extending from the base to the head.

Structure.—The component fibre-bundles of each muscle are inserted bipinnately on a tendon which begins high in the muscle and becomes free near the metatarso-phalangeal joint.

Insertion.—The first and second on each side of the base of the first phalanx of the second toe. The third and fourth on the lateral side of the bases of the phalanges of the third and fourth toes. Each tendon is adherent to the capsule of the neighbouring joint. They send no well-marked processes to the extensor tendons, as do those of the hand.

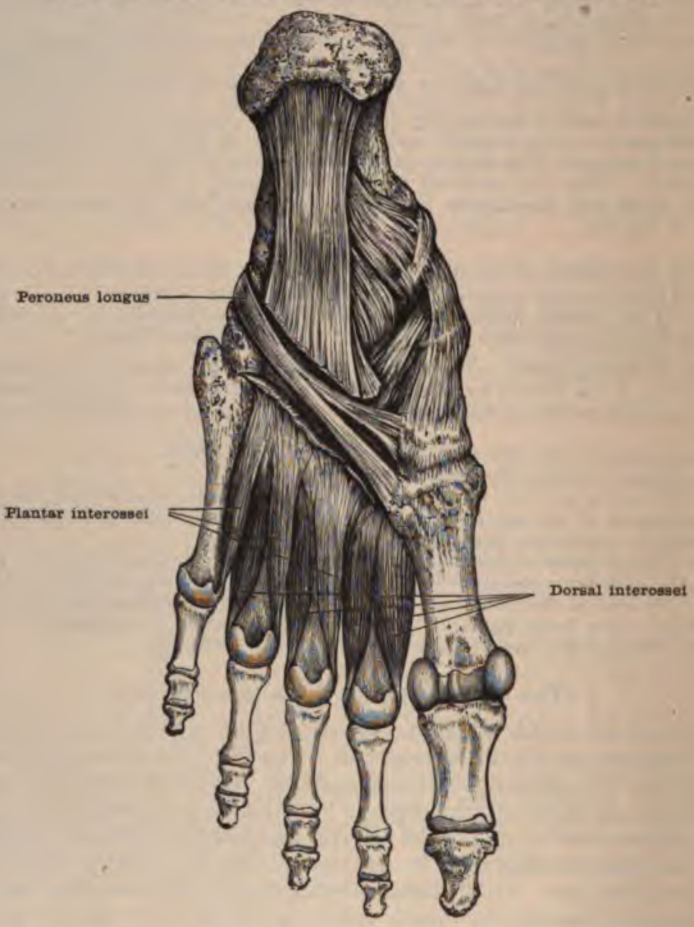
The interossei plantares.—Each plantar interosseus *arises*—(1) from the proximal third of the medial plantar surface of the shaft and from the base of the metatarsal on which it lies; and (2) from expansions of the long plantar ligament.

Structure and Insertion.—The obliquely placed fibre-bundles are longer than those of the dorsal interossei, and are inserted in a tendon which lies near the medial border of the muscle, becomes free near the metatarso-phalangeal joint, and is inserted into a tubercle on the medial side of the base of the first phalanx of the digit to which it goes.

Nerve-supply.—From the deep branch of the lateral plantar nerve several rami are given off for the interossei. The nerve of each muscle enters the plantar surface in the proximal third. The interosseous muscles of the fourth interspace, however, are usually supplied by a branch from the superficial ramus of the lateral plantar nerve.

Relations.—The interosseous muscles are covered on the plantar surface by a thin fascia on which the deep branches of the lateral plantar nerve and vessels run. The first dorsal interosseous adjoins medially the flexor hallucis brevis and laterally on the plantar surface of the second metatarsal, adjoins the second dorsal interosseous. Dorsal and plantar interossei then alternate across the plantar surface of the foot until the fifth metatarsal is reached. Here the third plantar interosseous adjoins the flexor brevis of the little toe.

FIG. 369.—FOURTH LAYER OF THE MUSCLES OF THE SOLE.



Action.—The chief axis of the foot may be taken to extend through the second toe. The dorsal interosseous muscles abduct—pull the digits to which they are attached away from this axis; the plantar interosseous muscles adduct—pull the digits towards the axis. The interossei all flex the first row of phalanges.

Variations.—The second dorsal interosseous may have no attachment to the third metatarsal.

BURSÆ

B. intermetatarsophalangeæ.—Four bursæ between the neighbouring sides of the heads of the metatarsal bones and dorsal to the transverse capitular ligaments. **B. mm. lumbricalium.**—Between the ends of the tendons of the lumbrical muscles and the transverse capitular ligaments. The three medial are more constant than the lateral.

For other bursæ in the foot, see pp. 461 and 465.

MUSCLES GROUPED ACCORDING TO FUNCTION*

In this table have been included not only the voluntary muscles described in the preceding section, but also several described in other parts of the book.

1. Facial muscles.
   These serve essentially to contract the various visceral orifices of the head or to retract the tissue surrounding them.
   - Ear.
     - Retractors: auricularis anterior, superior, and posterior.
   - Orbit.
     - (*a*) Retractor: Epicranius (occipito-frontalis). The levator palpebræ superioris, innervated by the third cranial nerve, serves to raise the upper lid of the eye.
     - (*b*) Contractors: orbicularis oculi, corrugator, and procerus.
   - Nasal orifice.
     - (*a*) Dilators: angular head of the quadratus labii superioris, transverse portion of the nasalis, and the dilatores naris.
     - (*b*) Contractors: pars alaris of the nasalis and the depressor septi nasi.
   - Oral orifice.
     - (*a*) Retractors:
       - Upwards: zygomaticus, quadratus labii superioris, caninus.
       - Lateralwards: zygomaticus, risorius, platysma, triangularis, buccinator.
       - Downwards: triangularis, quadratus labii inferioris, platysma.
     - (*b*) Contractors: orbicularis oris, compressor labii, incisivus labii inferioris and superioris
     - (*c*) Protractors of the lips: incisivus labii inferioris and superioris, mentalis.
2. Muscles acting on the eyeball (see Section on Eye).
   - To adduct the pupil: rectus medialis.
   - To abduct the pupil: rectus lateralis.
   - To rotate the pupil upward: rectus superior, in association with the obliquus inferior.
   - To rotate the pupil downward: rectus inferior, in association with the obliquus superior.
3. Muscles acting on the lower jaw.
   - (*a*) To raise it: masseter, temporal, internal pterygoid.
   - (*b*) To lower it: external pterygoid, digastric, mylo-hyoid, genio-hyoid, and the infrahyoid muscles. The weight of the jaw also plays a part in this movement.
   - (*c*) To protract it: external pterygoid and internal pterygoid.
   - (*d*) To retract it: the inferior dorsal portion of the temporal, the digastric, mylo-hyoid, and genio-hyoid.
   - (*e*) To produce lateral movements: the external pterygoid acting on one side carries the jaw towards the opposite side. The masseter draws it slightly towards the side on which the muscle lies. This action of the masseter is overcome by the internal pterygoid (Riegner).
4. Muscles acting on the hyoid bone.
   - (*a*) To elevate it: digastric, stylo-hyoid, stylo-glossus, mylo-hyoid, genio-hyoid, genio-glossus, hyo-glossus, and the middle constrictor of the pharynx.
   - (*b*) To depress it: thyreo-hyoid, sterno-hyoid, omohyoid, sterno-thyreoid.
   - (*c*) To protract it: genio-glossus (inferior portion), genio-hyoid, anterior belly of digastric, and the mylo-hyoid.
   - (*d*) To retract it: posterior belly of digastric, stylo-hyoid, and the middle constrictor of the pharynx.
5. Muscles acting on the larynx (see Section IX).
   - (*a*) To elevate it: thyreo-hyoid, stylo-pharyngeus, pharyngo-palatinus, the inferior constrictor of the pharynx, and the elevators of the hyoid bone.
   - (*b*) To depress it: sterno-thyreoid, sterno-hyoid, and omo-hyoid.
   - (*c*) To approximate the vocal cords: crico-arytenoideus lateralis; crico-arytenoideus posterior (in conjunction with the preceding muscle); vocalis; thyreo-arytenoideus; arytenoideus transversus.

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* The exact functions of many of the muscles have not yet been decisively determined. Anatomical studies, the construction of mechanical models, the electrical stimulation of the musculature, and observation of the muscular activities of normal individuals and of individuals in whom given muscles or sets of muscles are absent or paralysed, have all proved valuable methods of investigation, but each method has its drawbacks, and knowledge of the part actually played by individual muscles in the normal activities of the body is as yet merely approximate. Owing to the influence of gravity, the relations of other muscles to the skeleton, and similar factors, a given muscle may perform functions which would not be deduced from a simple study of the relations of the muscle to the skeleton. Thus the iliacus serves to flex not only the hip, but also the knee, and the hamstring muscles may flex the hip while flexing the knee. The functions ascribed to various muscles in the following tables, although an attempt has been made to base them upon the more recent work on the action of the muscles, must be taken to be merely approximately correct.

(*d*) To make the vocal cord tense: crico-thyreoideus, crico-arytenoideus lateralis crico-arytenoideus posterior, arytenoideus transversus.
(*e*) To widen the rima glottidis: crico-arytenoideus posterior.
(*f*) To relax the vocal cord: thyreo-arytenoideus (externus), vocalis.
(*g*) To constrict the aditus and vestibule of the larynx: arytenoideus obliquus, thyreo-arytenoideus.
(*h*) To widen the aditus and vestibule of the larynx: thyreo-epiglottideus.

6. Muscles acting on the tongue (see Section VIII).
(*a*) To elevate it: stylo-glossus (especially along the sides), glosso-palatinus, glosso-pharyngeus, and the elevators of the hyoid bone.
(*b*) To depress it: genio-glossus (in the centre), hyo-glossus (at the sides), chondro-glossus, and the depressors of the hyoid bone.
(*c*) To protrude it: genio-glossus (middle and inferior portions).
(*d*) To retract it: genio-glossus (anterior portion), stylo-glossus, chondro-glossus.
(*e*) To shorten it and make it bulge upwards: longitudinalis superior and inferior.
(*f*) To narrow it and make it bulge upwards: transversus linguæ.
(*g*) To flatten it : verticalis linguæ.

When the muscles work symmetrically, these movements are symmetrical; when they do not work symmetrically, the tongue is moved from side to side, rotated, etc.

7. Muscles acting on the palate and pharynx (see Section VIII).
(*a*) To narrow the pharyngeal opening of the tuba auditiva: levator veli palatini.
(*b*) To widen the isthmus of the tuba: levator veli palatini.
(*c*) To open the tube: tensor veli palatini.
(*d*) To raise and shorten the uvula: m. uvulæ.
(*e*) To depress the soft palate: glosso-palatinus, pharyngo-palatinus.
(*f*) To make tense the soft palate: tensor veli palatini.
(*g*) To lift the soft palate: levator veli palatini.
(*h*) To approximate the glosso-palatine arches (anterior pillars of the fauces): glosso-palatinus.
(*i*) To approximate the pharyngo-palatine arches (posterior pillars of the fauces): pharyngo-palatinus, superior constrictor of the pharynx.
(*j*) To constrict the pharynx: superior, middle, and inferior constrictors.
(*k*) To widen the pharynx: stylo-pharyngeus and the muscles which protract the hyoid bone.
(*l*) To elevate the pharynx: stylo-pharyngeus, pharyngo-palatinus.

8. Muscles acting on the head.
(*a*) To flex it: the supra- and infrahyoid muscles (except the posterior belly of the digastric), rectus capitis anterior, longus capitis.
(*b*) To extend it: sterno-cleido-mastoid, trapezius, splenius capitis, longissimus capitis, semispinalis capitis, obliquus capitis superior, rectus capitis posterior major and minor, and the posterior belly of the digastric.
(*c*) To bend it laterally: sterno-cleido-mastoid, rectus capitis lateralis, splenius capitis, longissimus capitis, semispinalis capitis, obliquus capitis superior.
(*d*) To rotate it: sterno-cleido-mastoid, trapezius, splenius capitis, longissimus capitis, semispinalis capitis, obliquus capitis superior and inferior, rectus capitis posterior major and minor.

9. Muscles acting on the spinal column.
(*a*) To flex it: sterno-cleido-mastoid, longus colli, longus capitis, psoas major and minor, scaleni, rectus abdominis, obliquus abdominis externus and internus, levator ani, coccygeus and sphincter ani.
(*b*) To extend it: splenius capitis, splenius cervicis, sacro-spinalis, semispinalis dorsi, cervicis and capitis, multifidus, rotatores, interspinales, levatores costarum, quadratus lumborum.
(*c*) To bend it laterally and rotate it: sterno-cleido-mastoid, scaleni, longus colli, trapezius, levator scapulæ, splenius capitis and cervicis, semispinalis dorsi, cervicis, and capitis, multifidus, rotatores, intertransversales, levatores costarum, psoas major and minor, quadratus lumborum, obliquus abdominis externus and internus, and rectus abdominis.

10. Muscles of respiration.
Quiet inspiration: the external intercostals, anterior portion of internal intercostals, diaphragm.
Enforced inspiration: in addition to the muscles mentioned above, the scaleni, sterno-cleido-mastoid, serratus posterior superior and inferior, rhomboids, serratus anterior, latissimus dorsi, pectoralis major and minor, and the extensors of the spinal column.
Quiet expiration: posterior part of internal intercostals, subcostales, and transversus thoracis.
Enforced expiration: in addition to the muscles mentioned above, the abdominal muscles, ilio-costalis lumborum and dorsi, and the quadratus lumborum.

The chief muscles of respiration are the intercostals; the diaphragm plays a minor part (Fick).

11. Muscles acting on the abdomen.
(*a*) Constriction of the abdominal cavity: obliquus abdominis externus and internus, the transversus and rectus abdominis, and the diaphragm, levator ani, and coccygeus.

(*b*) Reduction of pressure in the abdominal cavity: the muscles of inspiration, with the exception of the diaphragm, serve to lessen the compression of the abdominal viscera.

12. Action of the muscles of the perineal region (see Section X).

(*a*) To close anal canal: sphincter ani externus.

(*b*) To constrict the anal portion of the rectum: levator ani (pubo-coccygeal portion).

(*c*) To constrict the bulbus urethræ and the corpus cavernosum urethræ (corpus spongiosum): bulbo-cavernosus.

(*d*) To elevate the prostate gland: levator ani.

(*e*) To constrict the vagina: bulbo-cavernosus, levator ani (pubo-coccygeal portion).

(*f*) To cause erection of penis and clitoris: ischio-cavernosus, bulbo-cavernosus, and sphincter urethræ membranaceæ.

(*g*) To compress the urethra and the bulbo-urethral (Cowper's) gland: sphincter urethræ membranaceæ and the transversus perinei profundus.

(*h*) To support and lift the pelvic floor: levator ani, coccygeus, transversus perinei profundus and superficialis.

13. Muscles acting on the shoulder-girdle.

The two joints acted upon are the sterno-clavicular and the acromio-clavicular. The movements produced consist in lifting and lowering the shoulder, carrying it forwards and backwards, and rotating it.

(*a*) Elevation: levator scapulæ, trapezius (upper portion), sterno-cleido-mastoid, rhomboidei, serratus anterior (middle portion), omo-hyoid.

(*b*) Depression: trapezius (lower portion), pectoralis major (lower portion), pectoralis minor, subclavius, latissimus dorsi. The weight of the limb is likewise a factor.

(*c*) Forward movement: serratus anterior, pectorales major and minor.

(*d*) Backward movement: trapezius, rhomboidei, latissimus dorsi.

(*e*) Rotation.

Associated with abduction of the arm: serratus anterior (inferior portion), trapezius (superior part), levator scapulæ.

Associated with adduction of the arm: rhomboidei, trapezius (inferior part), serratus anterior (upper part), pectoralis major (pectoral portion), latissimus dorsi.

14. Muscles acting on the arm at the shoulder-joint.

(*a*) To abduct it: deltoid, supraspinatus, biceps (long head). The inferior part of the serratus anterior and the superior part of the trapezius are important in the early stages of abduction of the arm; the clavicular portion of the pectoralis major in supra-abduction.

(*b*) To adduct it: pectoralis major, latissimus dorsi, teres major, coraco-brachialis, triceps (long head). To these should be added the weight of the limb.

(*c*) To flex it: pectoralis major, deltoid (anterior portion), subscapularis, coraco-brachialis, biceps (short head), and the serratus anterior.

(*d*) To extend it: deltoid (posterior portion), teres major, latissimus dorsi. The upper and middle portions of trapezius, and the levator scapulæ, play an important part in extension of the arm.

(*e*) To rotate it outwards: infraspinatus, teres minor, and possibly the posterior portion of the deltoid.

(*f*) To rotate it inwards: subscapularis, deltoid (anterior fibres), teres major, latissimus dorsi, and pectoralis major.

15. Muscles acting on the forearm at the elbow-joint (arranged in order of force exerted according to W. Grohmann).

(*a*) Flexion at elbow.

Forearm supinated: brachialis, long head of biceps, brachio-radialis, short head of biceps, extensor carpi radialis longus, pronator teres, flexor carpi radialis, extensor carpi radialis brevis, palmaris longus.

Forearm in mid-position or pronated: brachialis, brachio-radialis, long head of biceps, short head of biceps, extensor carpi radialis longus, pronator teres, flexor carpi radialis, extensor carpi radialis brevis, palmaris longus.

(*b*) Extension at elbow: triceps (lateral, medial, and long heads), anconeus.

(*c*) Pronation of forearm.

Forearm extended: pronator teres, flexor carpi radialis, pronator quadratus, palmaris longus.

Forearm at right angles: pronator teres, brachio-radialis, flexor carpi radialis, pronator quadratus, extensor carpi radialis longus, palmaris longus.

Forearm flexed: pronator teres, brachio-radialis, flexor carpi radialis, pronator quadratus, extensor carpi radialis longus, palmaris longus.

(*d*) Supination.

Forearm extended: brachio-radialis, short head of biceps, long head of biceps, supinator, extensor carpi radialis longus, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor indicis proprius.

Forearm at right angles: short head of biceps, long head of biceps, supinator, abductor pollicis longus, extensor pollicis brevis, brachio-radialis (in pronation), extensor pollicis longus, extensor indicis proprius.
Forearm flexed: short head of biceps, long head of biceps, supinator, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor indicis proprius.

16. Muscle acting on the hand at the wrist.
    - (*a*) To flex it: flexor carpi radialis, palmaris longus, flexor carpi ulnaris, long flexors of the thumb and fingers, abductor pollicis longus.
    - (*b*) To extend it: extensor carpi radialis longus and brevis, extensor carpi ulnaris, and the extensors of the thumb and fingers.
    - (*c*) To abduct it: extensor carpi radialis brevis and longus, abductor pollicis longus, extensor pollicis brevis, flexor carpi radialis.
    - (*d*) To adduct it: flexor carpi ulnaris, extensor carpi ulnaris.
17. Muscles acting on the fingers.
    - (*a*) To flex all the joints: flexor digitorum profundus; all but the last: flexor digitorum sublimis; the metacarpo-phalangeal joint only: flexor digiti quinti brevis, the lumbricales, and interossei.
    - (*b*) To extend the fingers: extensor digitorum communis, extensor indicis proprius, extensor digiti quinti proprius; to extend the two interphalangeal joints: the lumbricales, interossei, and frequently the flexor digiti quinti brevis.
    - (*c*) To abduct from the axis passing through the centre of the middle finger: dorsal interossei, first two lumbricals, abductor digiti quinti.
    - (*d*) To adduct towards this axis: volar interossei, last two lumbricals, opponens and flexor digiti quinti brevis.
18. Muscles acting on the thumb.
    - (*a*) To flex all joints: flexor pollicis longus; the carpo-metacarpal and metacarpo-phalangeal joints: flexor brevis, the adductors, abductor brevis; the carpo-metacarpal joints: opponens pollicis, abductor longus.
    - (*b*) To extend all joints: extensor pollicis longus; the carpo-metacarpal and metacarpo-phalangeal joints: extensor pollicis brevis.
    - (*c*) To adduct: the adductor, flexor brevis, opponens, first dorsal interosseous, extensor longus.
    - (*d*) To abduct: the long and short abductors, the extensor brevis.
19. Muscles acting on the pelvis.
    - (*a*) To flex it: rectus abdominis, obliquus abdominis externus and internus, psoas major and minor.
    - (*b*) To extend it: sacro-spinalis and multifidus.
    - (*c*) To bend it laterally and rotate it: abdominal muscles, quadratus lumborum, and psoas muscles acting on one side.
20. Muscles acting on the thigh at the hip-joint.
    - (*a*) To flex it: ilio-psoas, sartorius, rectus femoris, pectineus, gracilis, adductor longus and brevis, tensor fasciæ latæ.
    - (*b*) To extend it: gluteus maximus, biceps, semitendinosus, semimembranosus, adductor magnus.
    - (*c*) To adduct it: gracilis, pectineus, adductor longus, brevis, and magnus, gluteus maximus (lower portion), quadratus femoris, obturator externus.
    - (*d*) To abduct it: gluteus medius and minimus, tensor fasciæ latæ, gluteus maximus; and when the hip is flexed, the piriformis, obturator internus, and gemelli.
    - (*e*) To rotate it inwards: tensor fasciæ latæ, gluteus medius (anterior portion), gluteus minimus, ilio-psoas.
    - (*f*) To rotate it outwards: piriformis, obturator internus and gemelli, obturator externus, quadratus femoris, gluteus maximus, gluteus medius (posterior portion), sartorius, pectineus, adductor longus, brevis, and magnus (superior and middle fasciculi), biceps.
21. Muscles acting on the leg at the knee-joint.
    - (*a*) To flex it: sartorius, gracilis, semitendinosus, semimembranosus, biceps, gastrocnemius, popliteus.
    - (*b*) To extend it: quadriceps femoris; (the tensor fasciæ latæ and gluteus maximus through the ilio-tibial band serve to keep the extended leg fixed).
    - (*c*) To rotate it inwards (when flexed): sartorius, gracilis, semitendinosus, semimembranosus, popliteus.
    - (*d*) To rotate it outwards (when flexed): biceps.
22. Muscles acting on the foot at the ankle-joint (arranged in order of force exerted, according to R. Fick).
    - (*a*) To flex it: tibialis anterior, extensor digitorum longus, extensor hallucis longus, peroneus tertius.
    - (*b*) To extend it: soleus, gastrocnemius, flexor hallucis longus, peroneus longus, tibialis posterior, flexor digitorum longus, peroneus brevis.
    - (*c*) To invert the foot at the inferior articulation of the talus (art. talocalcanea and talo-calcaneo-navicularis): soleus, gastrocnemius, tibialis posterior, flexor hallucis longus, flexor digitorum longus.
    - (*d*) To evert the foot at the inferior articulation of the talus: peroneus longus, peroneus brevis, extensor digitorum longus, peroneus tertius, extensor hallucis longus, tibialis anterior.

(*e*) To invert the foot at Chopart's (talo-navicular-calcaneo-cuboid) joint: tibialis anterior, tibialis posterior, flexor hallucis longus, flexor digitorum longus, extensor hallucis longus.

(*f*) To evert the foot at Chopart's joint: peroneus longus, peroneus brevis, extensor digitorum longus, peroneus tertius.

Muscles acting on the toes (arranged in order of force exerted, according to R. Fick).

(*a*) To flex all the joints: flexor digitorum longus, quadratus plantæ, and flexor hallucis longus; the first interphalangeal and the metacarpo-phalangeal joints of the four lateral toes: flexor digitorum brevis; the metacarpo-phalangeal joints: the lumbricals, interossei, abductor hallucis, adductor hallucis (oblique head), flexor hallucis brevis, abductor digiti quinti, flexor digiti quinti brevis.

(*b*) To extend all joints: extensor digitorum longus, extensor hallucis longus, extensor digitorum brevis; the interphalangeal joints: the lumbricales, and the adductors and abductors of the big and little toes.

(*c*) To abduct from an axis passing through the second toe; abductor hallucis, dorsal interossei, abductor digiti quinti, first lumbrical.

(*d*) To adduct towards this axis: adductores hallucis, plantar interossei, three more lateral lumbricals.

(*e*) To draw together the ends of the metatarsals: the transverse head of the adductor of the big toe.

SECTION V

THE ORGANS OF CIRCULATION

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THE PERICARDIUM

THE circulatory system includes the heart, the arteries, the veins, and the lymphatics. The heart is situated in the middle mediastinal space of the thorax, between the two lungs, and, together with the large vessels at its base, is enclosed in a membranous sac, the pericardium.

The **pericardium** is a cone-shaped, fibro-serous sac which surrounds the heart. Its apex is above at the root of the great vessels, and its base below, adherent to the diaphragm. Its connection with the diaphragm is in part to the central tendon and in part to the muscle, especially on the left side. The **fibrous layer** is strong and inelastic, made of interlacing fibres. Its connection with the central tendon of the diaphragm is close and intimate, it being bound firmly to the caval opening, but elsewhere it is attached loosely by means of areolar tissue. Above, it is lost on the sheaths of the great vessels, all of which receive distinct investments, with the single exception of the inferior vena cava, which pierces it from below. The aorta, superior vena cava, both divisions of the pulmonary artery, the ligamentum arteriosum, and the four pulmonary veins, are all ensheathed in this manner. The fibrous portion of the pericardium, through the sheaths prolonged over the great vessels, becomes continuous above with the deep cervical fascia. Two variable bands of fibrous tissue, the **sterno-pericardial ligaments,** connect the front of the pericardium, above and below, with the posterior surface of the sternum.

The **serous layer** is smooth and glistening, made of a membrane of endothelial cells resting on connective tissue rich in elastic fibres. It lines the fibrous sac, making a parietal layer, and is reflected over the heart, making a visceral layer. At the line of reflection a series of pouches are formed between the various vessels. A tubular prolongation surrounds the root of the pulmonary artery and the aorta in common, separating them from the rest of the vessels and making a passage behind them, the so-called **transverse sinus** of the pericardium, which connects the right and left sides of the pericardial sac. It lies in front of the atria.

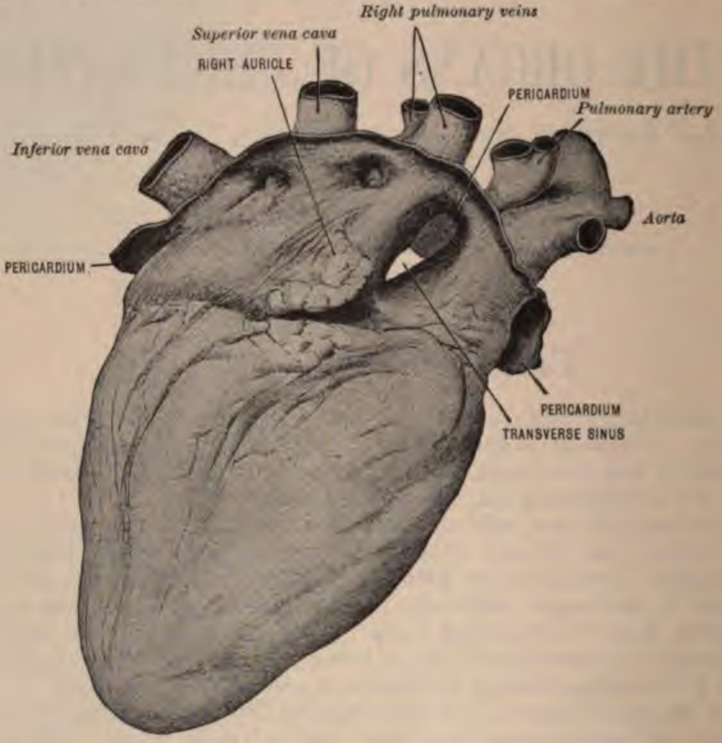
As seen from behind, the cavity of the pericardium is also prolonged by pouches between the venæ cavæ and the right and left pulmonary arteries and veins, although none of these vessels receives as complete an investment of the pericardium as the aorta and pulmonary artery. The covering of the inferior vena cava is slight, for that vessel enters the auricle just after passing through the diaphragm.

The **vestigial fold of the pericardium** is a doubling of the serous layer which passes between the left pulmonary artery above and the left superior pulmonary vein below. It contains, besides some fatty and areolar tissue, the shrunken remains of the left superior vena cava. It is connected above with the left superior intercostal vein, and below with the left atrium and its **oblique vein (oblique vein of**

Marshall)—these veins with the coronary sinus having originally formed portions of the left upper cava.

Relations.—In front are found the thymus gland or its remains, areolar tissue, the sterno-pericardial ligaments, the left transversus thoracis muscle, the internal mammary vessels, the anterior margins of the pleural sacs and lungs, and the sternum. Laterally, it is overlapped by the lungs with their pleural sacs, and it is in contact with the phrenic nerves and their accompanying vessels. Posteriorly, it is in relation with the œsophagus and vagus nerves, the descending aorta, the thoracic duct and vena azygos, and the roots of the lungs.

FIG. 370.—ANTERIOR VIEW OF THE HEART AND PERICARDIUM. (After Henle.)



Vessels.—The arteries of the pericardium are derived from the pericardiac, œsophageal, and bronchial branches of the thoracic aorta and from the internal mammary and phrenic arteries.

THE HEART

The **heart**—enclosed in the pericardium—occupies the greater part of the middle mediastinal space. It is a somewhat flattened, cone-shaped, hollow, muscular organ. It is attached only at its base by the roots of the great vessels; otherwise it can move freely in the pericardium.

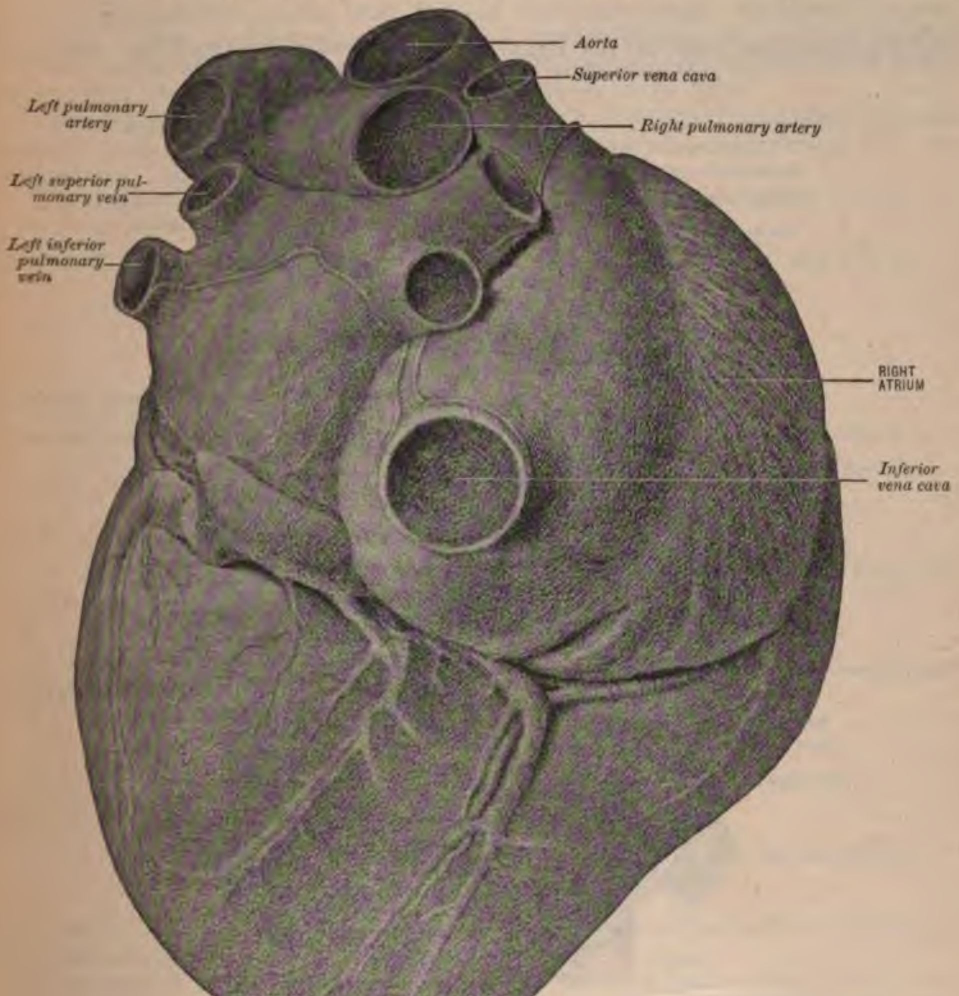
Position.—In the adult the heart lies obliquely behind the lower two-thirds of the sternum, projecting considerably to its left side. Its **base** is directed slightly upwards and backwards and to the right, its **apex** downwards and forwards and to the left. The base corresponds to the middle four thoracic vertebræ; and the **apex** strikes the chest-wall between the fifth and sixth rib cartilages on the left side, at a spot about 5 cm. (2 in.) below the nipple, and 2·5 cm. (1 in.) to its sternal side, or 8 cm. (3¾ in.)

from the middle line of the sternum. Owing to its oblique position, the two surfaces of the heart are termed the sterno-costal and the diaphragmatic. In the course of development the heart has been turned so that the right atrium lies directly over the caval opening of the diaphragm, when the body is erect.

The **lower border** is formed by the right ventricle and rests on the central tendon of the diaphragm. It is a curved line extending from the apex to the right edge of the sternum near its junction with the sixth cartilage.

The **lateral borders** may be completed by drawing curved lines upwards from the ends of the lower border to the base of the heart. The right border consists entirely of the right atrium, and the left almost entirely of the left ventricle.

FIG. 371.—POSTERIOR SURFACE OF THE HEART. (After His.)


Aorta
Superior vena cava
Left pulmonary artery
Right pulmonary artery
Left superior pulmonary vein
Left inferior pulmonary vein
RIGHT ATRIUM
Inferior vena cava

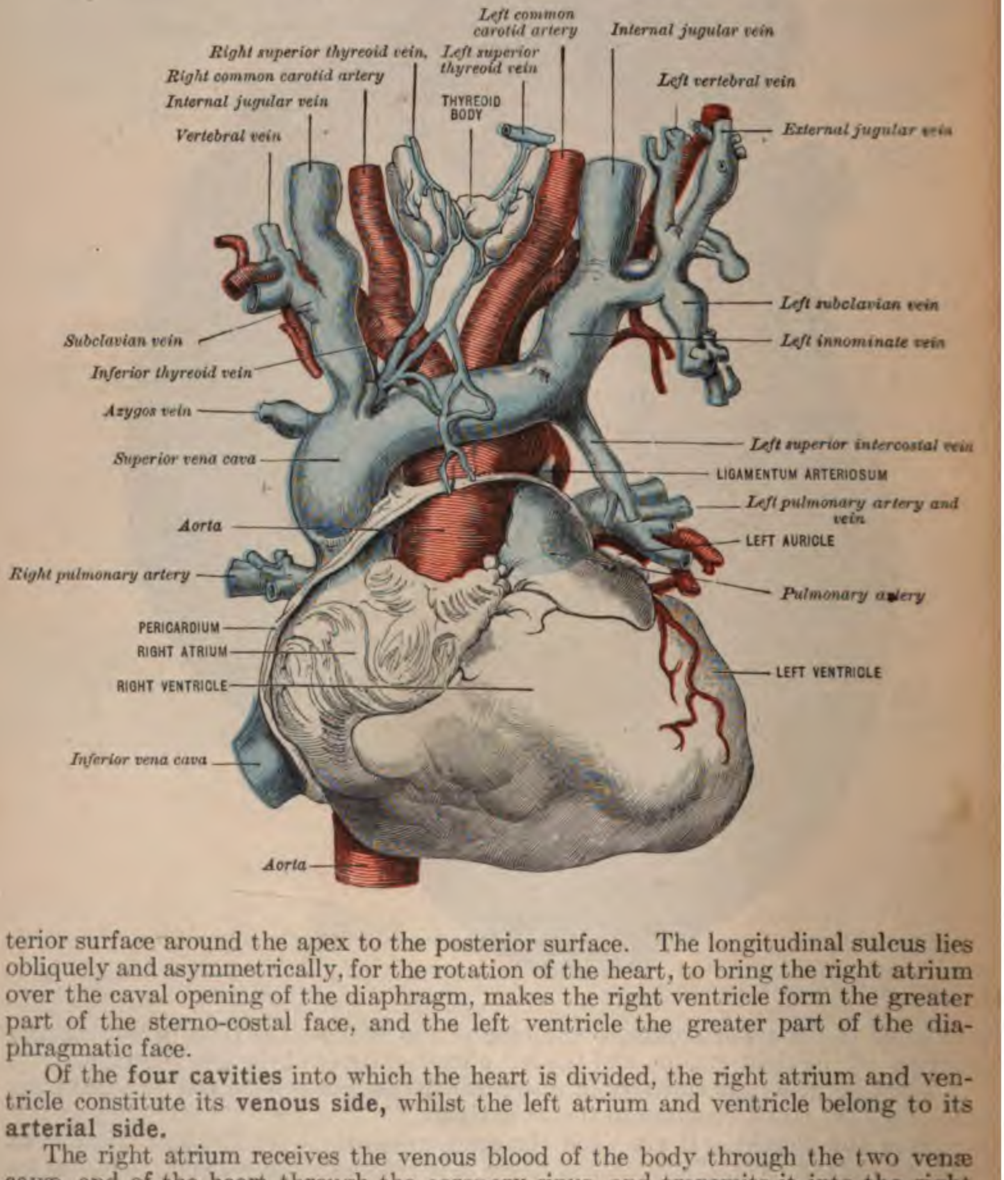
The position of the coronary (atrio-ventricular) sulcus is indicated by a line from the third left costal cartilage to the sixth right.

Size and weight.—In the adult the heart measures about 12·5 cm. (5 in.) from base to apex, 8·7 cm. (3½ in.) across where it is broadest, and 6·2 cm. (2½ in.) at its thickest portion. In the male its weight averages about 312 gm. (eleven ounces), and in the female about 255 gm. (nine ounces). It increases both in size and weight up to advanced life, the increase being most marked up to the age of twenty-nine years. Measurements of the heart must take into account the condition of systole or diastole.

The **sterno-costal surface** of the heart looks upwards and forwards, and is formed for the most part by the right half of the heart. Its **diaphragmatic surface** is formed almost entirely by the ventricles. The borders which divide the two surfaces of the heart meet near the apex; the right border is thin and rather longer than the left, whilst the latter border is thick and rounded.

The atria are divided from the ventricles by a transverse groove, the **coronary sulcus** or **atrio-ventricular groove,** which is interrupted in front by the origin of the pulmonary artery. The ventricles are similarly divided from each other by the **longitudinal sulcus** or **interventricular groove,** which is continuous from the anterior surface around the apex to the posterior surface. The longitudinal sulcus lies obliquely and asymmetrically, for the rotation of the heart, to bring the right atrium over the caval opening of the diaphragm, makes the right ventricle form the greater part of the sterno-costal face, and the left ventricle the greater part of the diaphragmatic face.

Fig. 372.—Anterior View of the Heart with the Larger Vessels. (By permission, Museum of the Royal College of Surgeons.)


Left common carotid artery
Internal jugular vein
Right superior thyreoid vein,
Left superior thyreoid vein
Right common carotid artery
Left vertebral vein
Internal jugular vein
THYREOID BODY
Vertebral vein
External jugular vein
Left subclavian vein
Subclavian vein
Left innominate vein
Inferior thyreoid vein
Azygos vein
Left superior intercostal vein
Superior vena cava
LIGAMENTUM ARTERIOSUM
Left pulmonary artery and vein
Aorta
LEFT AURICLE
Right pulmonary artery
Pulmonary artery
PERICARDIUM
RIGHT ATRIUM
RIGHT VENTRICLE
LEFT VENTRICLE
Inferior vena cava
Aorta

Of the **four cavities** into which the heart is divided, the right atrium and ventricle constitute its **venous side,** whilst the left atrium and ventricle belong to its **arterial side.**

The right atrium receives the venous blood of the body through the two venæ cavæ, and of the heart through the coronary sinus, and transmits it into the right ventricle. The right ventricle in turn transmits the venous blood to the lungs through the pulmonary artery. From the lungs it is returned arterialised to the left atrium of the heart by the pulmonary veins. From the atrium it passes into the corresponding ventricle, and thence through the aorta and its branches to all parts of the body, including the heart itself.

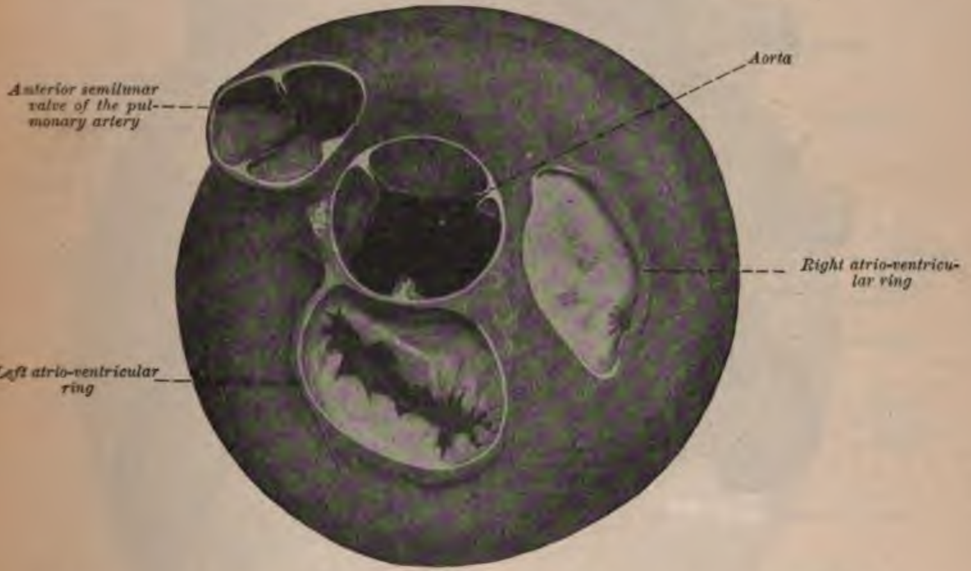
THE RIGHT ATRIUM

The **right atrium (auricle)** forms the upper and right part of the heart; below it is the right ventricle; to the inner side, in front, it embraces the root of the pulmonary artery; and behind it is separated from the left atrium by the atrial septum, and is adjacent to the right inferior pulmonary vein. It is made of a thin muscular wall and is lined by a smooth and delicate membrane, the **endocardium,** which is continuous with the inner coats of the blood-vessels. Its cavity is separable into a large quadrangular portion, the **atrium** proper, and a much smaller portion, the **auricle (auricular appendix),** which projects over the root of the aorta. This atrium forms the right and fore part of the base of the heart.

Openings.—There are three chief openings into the right atrium, that from the superior vena cava, that from the inferior vena cava, and the opening into the ventricle.

The **superior caval opening** is at the upper and back part of the atrium. It is without a valve and is directed downwards and forwards towards the atrio-ventricular opening.

FIG. 373.—VIEW OF THE HEART TO SHOW THE POSITION OF THE SEMILUNAR VALVES. (After Krehl.)


Anterior semilunar valve of the pulmonary artery
Aorta
Right atrio-ventricular ring
Left atrio-ventricular ring

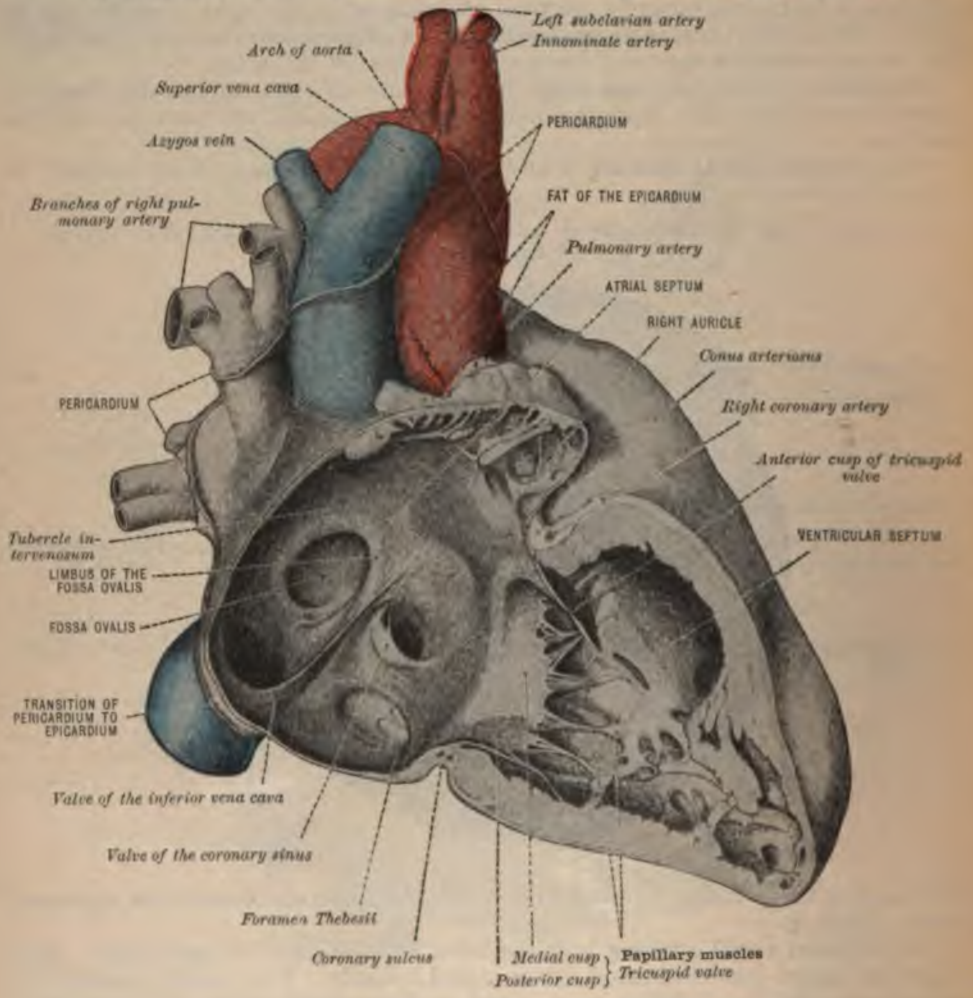
The **inferior caval opening** is at the lower and back part of the atrium. It is somewhat larger, and is directed upwards and inwards. It is usually guarded by a semilunar fold, the **inferior vena caval** or **Eustachian valve,** which is much larger in fœtal life, and which then serves to direct the current of blood through the foramen into the left atrium. It is attached by its convex margin to the front and left side of the vein, its free concave edge looking upwards and to the right. The left cornu or horn of the crescent is continuous with the limbus of the fossa ovalis, whilst the right horn is lost on the atrial wall. The Eustachian valve contains interlacing muscular fibres; it is often incomplete and sometimes perforated.

The **atrio-ventricular opening (ostium venosum)** is in the lower front part of the atrium. Smaller openings into the atrium are made by the coronary sinus and the foramina Thebesii. The orifice of the **coronary sinus** is between the lower caval and the atrio-ventricular opening. It returns the blood from the heart substance, and is guarded by a semilunar or sometimes double valve, known as the coronary valve, or **valve of Thebesius.** Like the Eustachian valve, it is formed of a fold of the endocardium, and serves to direct the blood current, but does not prevent regurgitation. It is sometimes perforated, and occasionally presents the most delicate lacework.

The foramina Thebesii.—The greater number of these small orifices end blindly, but the rest are the terminations of minute veins from the muscular substance (**venæ minimæ cordis**). One of these, more constant than the others, the **vena Galeni** (right marginal), usually opens below the superior cava, on the septal wall.

The **cavity of the right atrium** is smooth, except upon its anterior wall, and within the appendix, where it is ridged with muscular bands (the **musculi pectinati**), which terminate, above, along a ridge, the crista terminalis.

Fig. 374.—Anterior View of the Right Chambers of the Heart with the Great Vessels. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Left subclavian artery
Innominate artery
Arch of aorta
Superior vena cava
Azygos vein
PERICARDIUM
Branches of right pulmonary artery
FAT OF THE EPICARDIUM
Pulmonary artery
ATRIAL SEPTUM
RIGHT AURICLE
Conus arteriosus
PERICARDIUM
Right coronary artery
Anterior cusp of tricuspid valve
VENTRICULAR SEPTUM
Tubercle intervenosum
LIMBUS OF THE FOSSA OVALIS
FOSSA OVALIS
TRANSITION OF PERICARDIUM TO EPICARDIUM
Valve of the inferior vena cava
Valve of the coronary sinus
Foramen Thebesii
Coronary sulcus
Medial cusp
Posterior cusp
Papillary muscles
Tricuspid valve

The crista terminalis corresponds externally with a sulcus, the sulcus terminalis, which runs across the atrium from the front of the superior cava to the right of the inferior cava, and both the groove and the ridge indicate the line of union of the sinus venosus of the fœtus with the auricle proper (fig. 371).

At the lower part of the posterior wall or septum which divides the two atria, and just above the orifice of the **inferior cava,** is a smooth oval depression, the **fossa ovalis.** It marks the position of an opening in the fœtal heart, between the two atria, and is bounded anteriorly by a well-marked rounded edge, the **limbus of**

the fossa ovalis. Beneath its upper margin a little valvular pouch may usually be noticed which leads into a small orifice passing into the left atrium.

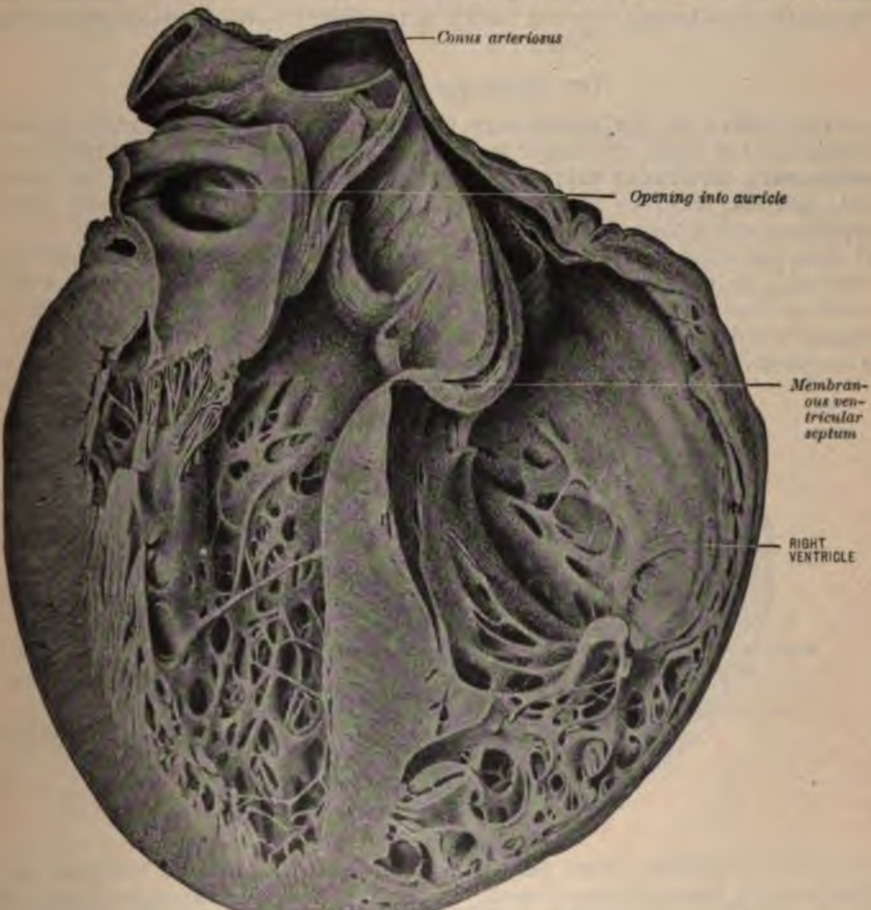
The **tubercle intervenosum** (**tubercle of Lower**)—which is placed on the right of the cavity between the orifices of the two cavæ—is well marked in some of the lower animals, but it is quite an insignificant eminence in man.

THE RIGHT VENTRICLE

The **right ventricle** forms the larger part of the sterno-costal face of the heart. In front it is convex; but below, where it rests upon the diaphragm, it is flattened. It forms the whole of the lower border (*margo acutus*) of the heart, but it does not reach the apex, which is formed entirely by the left ventricle.

It lies behind the lower part of the body of the sternum and the cartilages of the fifth, sixth, and seventh ribs of the left side.

Fig. 375.—The Inner Surface of the Ventricles, Anterior Half. (After His.)



In form the ventricle is triangular, in section semilunar, and its walls are much thinner than those of the left ventricle. Its upper and left angle is continuous with the root of the pulmonary artery; and upon opening the cavity the two are seen to be continuous through a cone-shaped prolongation—the infundibulum or **conus arteriosus.**

At the opposite angle of the base there is a second and larger opening, leading from the right atrium, the **ostium venosum** (**atrio-ventricular orifice**). It lies below and to the right of the pulmonary orifice. The apex of the ventricle points to the left.

The two openings just named are guarded by valves and separated by a rounded muscular projection of the ventricular wall. The **inner surface,** or **body,** of the ventricle presents a somewhat complicated arrangement of muscular **ridges, bands,** and **columns,** which become smaller, more numerous, and more closely interlaced at the apex and near the margin, but disappear in the conus arteriosus.

These projections, or **trabeculæ (columnæ) carneæ,** are usually divided into three sets:—(1) mere ridges; (2) bands attached to either end but elsewhere free; and (3) the **musculi papillares,** which are connected with the atrio-ventricular valve.

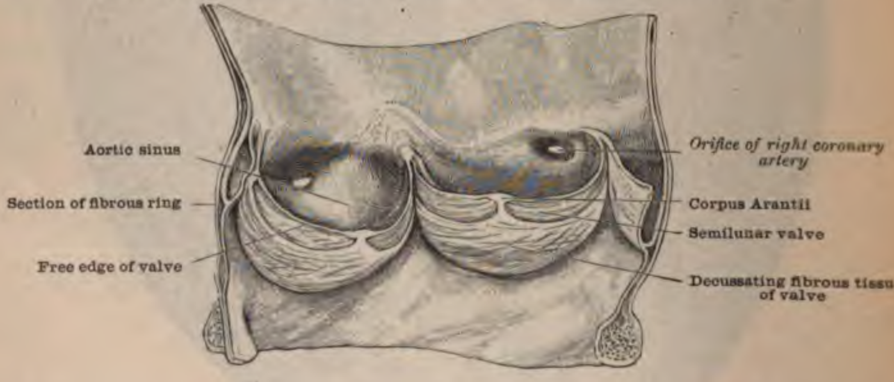
A special so-called **moderator band,** which is constant in the sheep, is occasionally a well-marked structure in the human heart, stretching between its anterior and septal walls. The **musculi papillares** are attached by their broad end to the ventricular wall, and by their extremities to tendinous cords (**chordæ tendineæ**), which prevent the valves guarding the atrio-ventricular opening from being forced back into the atrium during the contraction of the ventricle. Three of these are larger and more constant than the rest: an **anterior,** connected with the front wall above the moderator band; a **right,** near the margin, which is also attached to the anterior wall; and a **posterior,** which arises from the septum. The septal wall of the ventricle so bulges into the cavity as to make its cross-section appear crescentic.

THE OPENINGS AND THEIR VALVES

The **orifice of the pulmonary artery** is circular and obliquely placed at the summit of the conus arteriosus near the septum. It is guarded by three valves, the **pulmonary semilunar valves.** One segment of the valve is anterior, one is to the left, and the other to the right (fig. 373). Immediately above and behind each semilunar valve there is a pouch or **sinus of Valsalva.**

The valves are thin but strong, being made of a fibrous layer covered with endocardium. In the centre of the free straight edge of each valve there is a little fibrocartilaginous nodule, the **nodule** or **corpus Arantii,** and the margin itself is further strengthened by a delicate tendinous band. Another fibrous band in like manner strengthens the convex attached portion of the valve, and from this a third set of obliquely interlacing fibres pass throughout the whole valve towards the nodule. Two narrow crescent-shaped areas, the **lunulæ,** near the free edge on each side of the nodule, remain almost free from this fibrous invasion, so that they are thinner than the rest of the valve. The line of closure of the valves is not the free margins but the bases of the lunulæ, so that the crescents are in apposition and project into the artery. A fibrous ring strengthens the pulmonary orifice, giving attachment below to the muscular fibres of the heart; whilst above, opposite the aortic sinuses (sinuses of Valsalva), it is deeply hollowed into three semilunar notches. The valves are attached to the edges of these notches as well as to the horns which project inwards and separate them from one another. In the aortic valves these characters are present and more strongly marked (fig. 376).

FIG. 376.—INTERIOR VIEW OF THE AORTIC SEMILUNAR VALVES.



The **atrio-ventricular opening** is oval and guarded by the **tricuspid valve.**

The three triangular flaps of this valve are continuous with one another at their broad ends, and so form a continuous ring around the orifice; but beyond, they project with jagged and sharply dentated edges towards the apex of the ventricle.

The chordæ tendineæ, which chiefly arise from the papillary muscles already described, pass to the free borders of the valve. The largest segment of the valve is placed in front, between the atrio-ventricular orifice and the conus arteriosus, the smallest behind near the septum, and the third, which is the most movable, is situated on the right.

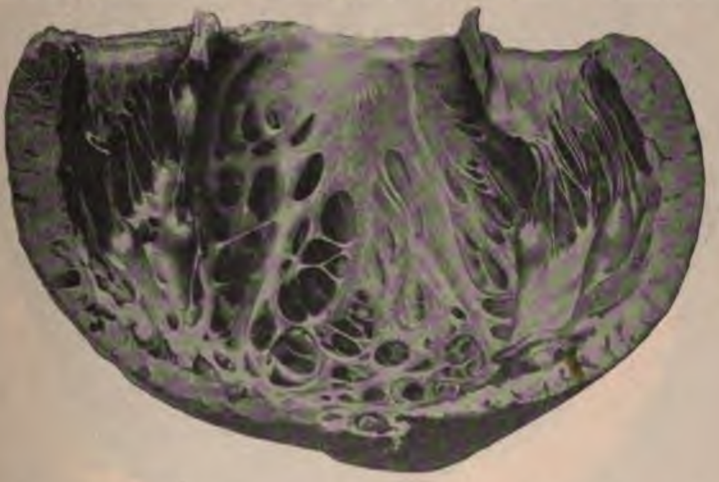
Smaller segments intervene between the larger flaps. The chordæ tendineæ, which arise in groups from the papillary muscles, divide as they pass to be attached to the edges and ventricular surfaces of the neighbouring segments. Additional cords are furnished from the ventricular walls, and especially from the septum to the small segment, and some of these are provided with little papillary muscles.

The segments of this valve, except at the extremities and margins, contain abundant fibrous and a small amount of muscular tissue. They are attached by their thickened bases to a fibrous ring which surrounds and strengthens the orifice. The surfaces of the valves are smooth, whilst the edges to which the chordæ tendineæ are attached form an arched interlacement, which has been well likened to the fan tracery of Gothic architecture. (Macalister.)

THE LEFT ATRIUM

The **left atrium** (auricle) is placed behind the roots of the aorta and pulmonary artery, with the right atrium overlapping it. Behind, it receives on each side the pulmonary veins, and it is separated by the pericardium from the œsophagus and the descending thoracic aorta. Its narrow and much curved auricle or appendix arches round the root of the pulmonary artery, and is the only part of the atrium to be seen from the front. The **cavity** of the atrium is smooth, with the exception of the auricle (appendix), in which the musculi pectinati are well marked.

FIG. 377.—THE INNER SURFACE OF THE LEFT VENTRICLE. (After Krehl.)



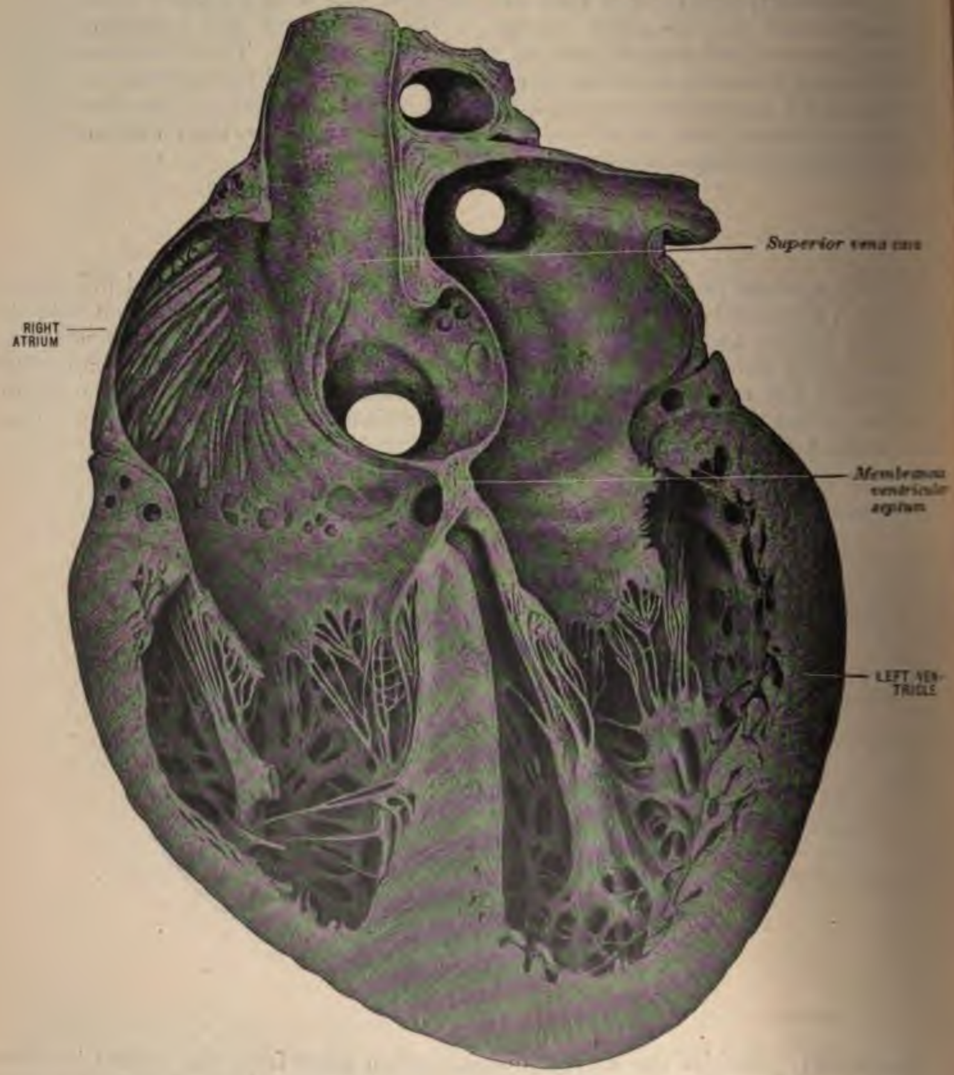
Openings.—Besides the narrow opening which leads from the atrium into the auricle, the left atrium presents posteriorly the orifices of the four **pulmonary veins,** two of which sometimes have a single mouth, whilst an additional vein may be present, especially on the right side. The oval **atrio-ventricular opening** is placed below and in front. Several small orifices, the **foramina Thebesii,** are also to be found in the walls of the cavity. A crescentic indentation on the septal wall, with its concavity upwards and placed above the level of the fossa ovalis, indicates the upper border of the valve, which has grown upwards to obliterate the foramen ovale, but which now is adherent and forms part of the wall dividing the two auricles. As already observed, a small oblique orifice frequently persists.

THE LEFT VENTRICLE

The **left ventricle** forms the chief part of the lower surface of the heart, with apex and left border. It is somewhat longer and narrower than the right. cavity is conical with the apex below, and it is somewhat ovoid in transverse sect Its muscular wall, which is much thicker than that of the right ventricle, is thi nest at the apex and thickest at the junction of the upper and middle thirds.

The **trabeculæ carneæ** are numerous, small, and closely reticulated, giving the interior of the ventricle, especially near the apex, a cavernous appearance.

FIG. 378.—THE ATRIO-VENTRICULAR VALVES. (After His.)

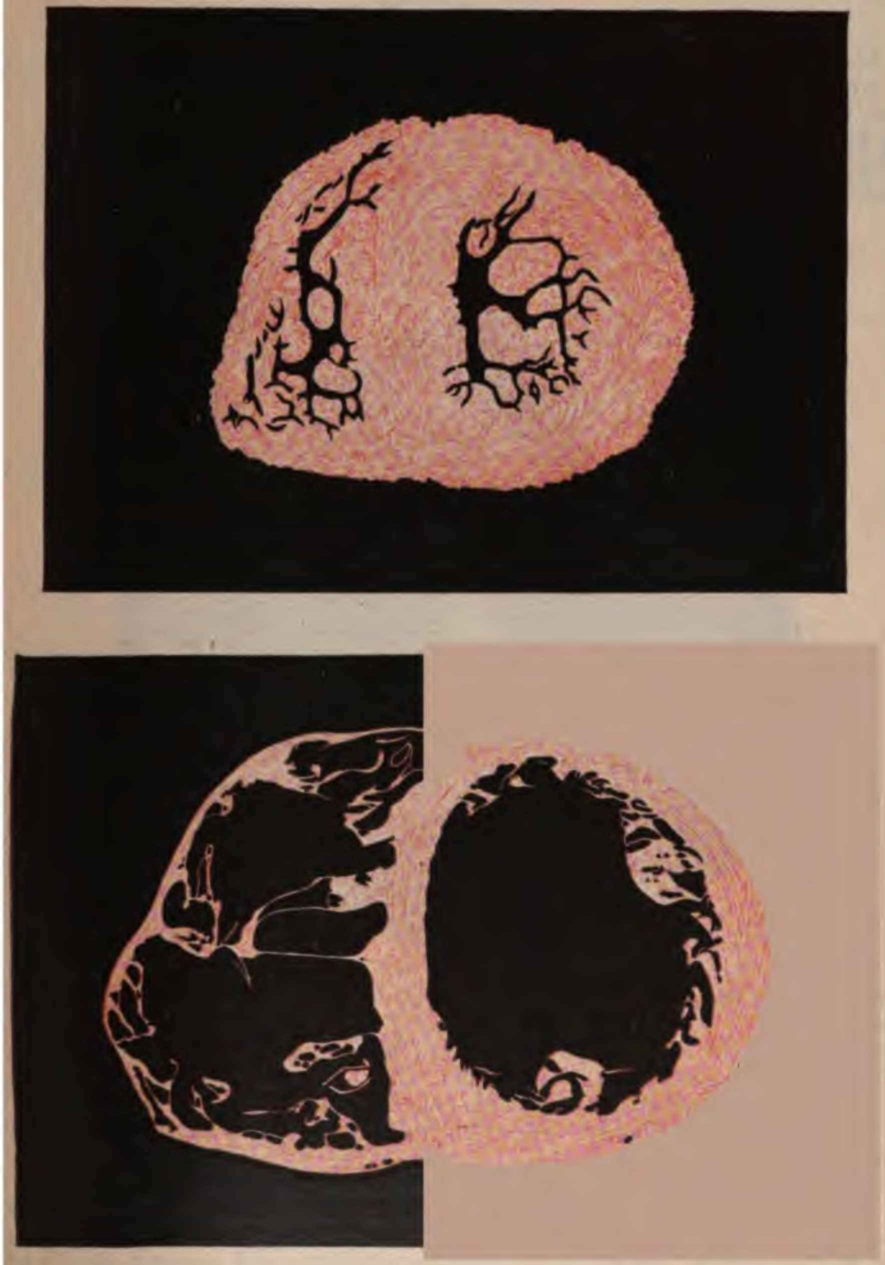


The **musculi papillares** are usually represented by two large, sometimes compound, muscular pillars, which arise from the anterior and the posterior wall respectively, and from these the **chordæ tendineæ** pass to the edges and surfaces of the two segments of the bicuspid valve.

The **orifice of the aorta** looks somewhat forwards, and is guarded by three **semilunar valves,** which are similar in structure, but present more strongly marked characters than are to be found in the corresponding valves of the pulmonary artery. One of these segments is placed to the left, one to the right, and the other posteriorly.

he sinus behind the right and left flaps are the openings of the right and left nary arteries which supply the heart with blood. The base of the valve is sur- nded by a fibrous ring, similar to that which strengthens the pulmonary orifice, the walls of that portion of the cavity which lies immediately below it, the ic vestibule, are entirely fibrous (fig. 373 and 376).

FIG. 379.—SECTION OF THE VENTRICLES IN SYSTOLE AND DIASTOLE. (After Krehl.)



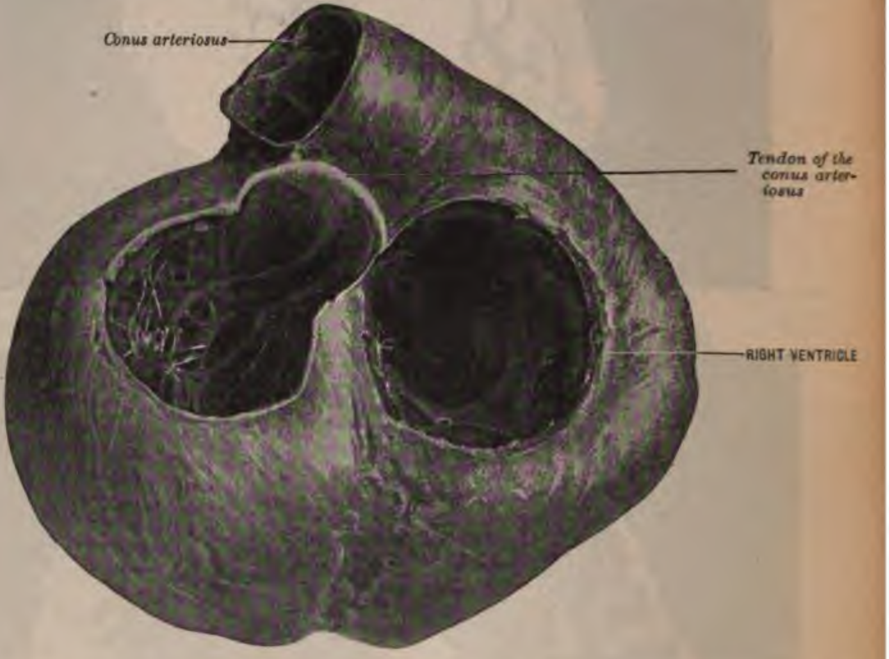
The **atrio-ventricular opening** is guarded by the **bicuspid valve.** Its two qual segments are larger and thicker than those on the right side of the heart, ugh the orifice itself is somewhat smaller, and they are similarly separated by ller lobes or cusps. Of the two segments, the one, which is the larger and the re free and smooth, is placed in front and to the right between the auriculo- tricular and the aortic openings, whilst the other lies behind and to the left. The fibrous ring surrounding the orifice serves to give attachment to muscular fibres as well as to the valves. Its right border is tied to the aortic ring by fibrous tissue, which also extends to the ring surrounding the tricuspid valve.

The interventricular septum which separates the cavities of the ventricles is thickest below. In the greater part of its extent it consists of muscular tissue, but its upper portion, which intervenes not only between the two ventricles but also between the left ventricle and right auricle, is a fibrous septum devoid of muscle-fibres.

THE ARCHITECTURE OF THE HEART

As has been said, the heart is a hollow organ made chiefly of muscle. It is covered by a serous membrane, the pericardium. Beneath the pericardium there is always some fat deposited, especially in the coronary and longitudinal sulci at the base. The heart is lined by a layer of endothelial cells, the endocardium, beneath which is considerable elastic tissue, and the elastic fibres also penetrate between the muscle bundles and form a rich plexus at the root of the aorta. In systole this elastic tissue must be much compressed so that an elastic rebound follows in the beginning of diastole.

FIG. 380.—HUMAN HEART FIXED IN DIASTOLE, SHOWING THE ATRIO-VENTRICULAR RINGS. (After Krehl.)



In studying the structure of the heart it is necessary to note the great change in form between systole and diastole (fig. 379). This change is the natural consequence of the arrangement of the heart-muscle fibres, or, to put it the other way, the bands of heart-muscle fibres are so put together as to produce the most effective emptying of the heart.

In order to understand the architecture of the heart it is necessary to get a clear picture of the fibrous rings and bands which are the tendons for the heart-muscle fibres. There are four sets of tendons: three of them, the two atrio-ventricular rings and the tendon of the conus arteriosus, described and pictured by Krehl, are on the outside of the heart. The rings are best seen in specimens which are macerated so as to soften the connective tissue; it is then easy to pull the atria away from the ventricles, thereby exposing the rings. The tendon of the conus arteriosus is shown in a dog's heart in fig. 381. It is less plain in the human heart. It extends from the right atrio-ventricular ring along the posterior surface of the conus arteriosus, between it and the aorta, the aorta and pulmonary artery being joined along its line. On the inside of the heart is the fourth set of tendons, which are known as the chordæ tendineæ and attach the papillary muscles to the free borders of the valves. The arrangement of these papillary muscles is an integral part of the arrangement of the heart layers. On the left side there are three groups of the muscles—one set of numerous small muscles along the septum, one large anterior muscle, and one similar posterior one. In the right ventricle the groups are less marked,

FIG. 381.—DOG'S HEART FIXED IN DIASTOLE TO SHOW THE ATRIO-VENTRICULAR RINGS AND THEIR RELATION TO THE VALVES. THE HEART IS SEEN FROM BEHIND. (After Krehl.)

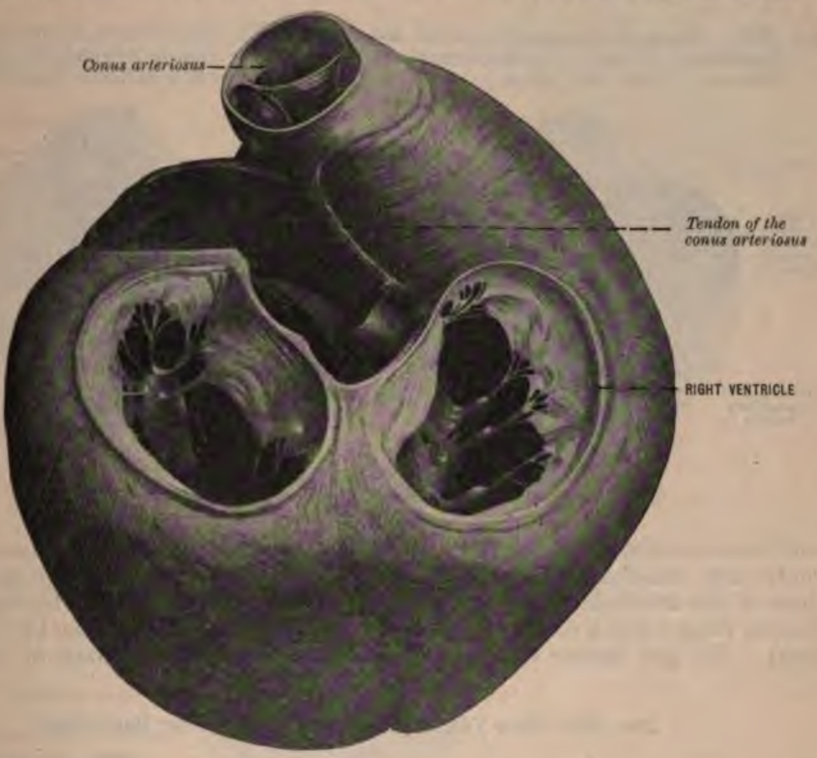
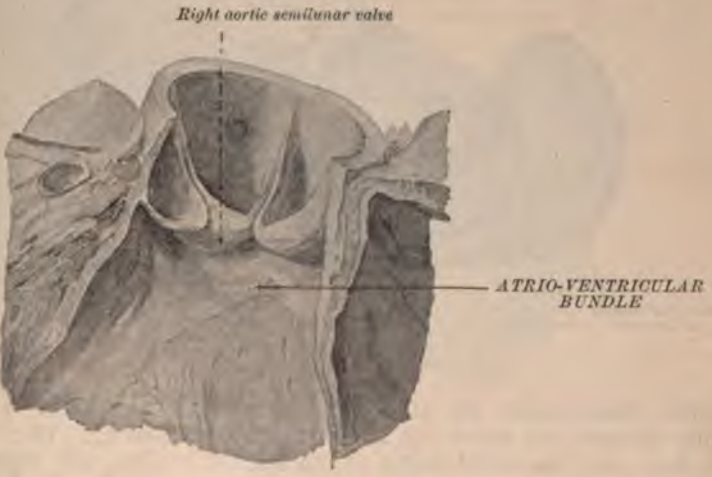

Conus arteriosus
Tendon of the conus arteriosus
RIGHT VENTRICLE

FIG. 382.—THE ATRIO-VENTRICULAR BUNDLE SEEN FROM THE RIGHT VENTRICLE. (After Retzer.)


Right aortic semilunar valve
ATRIO-VENTRICULAR BUNDLE

but they are also in three sets, one for each flap of the tricuspid valve. It will be seen that these two sets of tendons, the one set at the base of the heart, and the other forming the chordæ tendineæ, mark the origin and insertion of the heart-muscle bands.

Of these four sets of tendons, only two, namely, the rings, have any connection with the musculature of the atria, while all four form the origin and insertion of the ventricular muscles. The intrinsic muscles of the atria have no connection with those of the ventricles, and until recently it was thought that the fibrous atrio-ventricular rings made a complete separation of the musculature of the two parts of the heart. His and Retzer have shown that there is a small bundle of muscle-fibres which does connect the atria with the ventricles (fig. 382). It runs in the ventr ular septum just below the membranous part (see fig. 378); it arises in the ri atrium and the septal leaflet of the tricuspid valve, and inserts in the ventricu septum. The importance of this atrio-ventricular bundle in the function of t heart is brought out by Erlanger, who has produced heart block by clamping t bundle, thus showing that through it the sequence of the heart-beat is maintained

FIG. 383.—DIAGRAM OF ONE ANTERIOR AND ONE POSTERIOR SUPERFICIAL BUNDLE SEEN FROM BEHIND. (After MacCallum.)

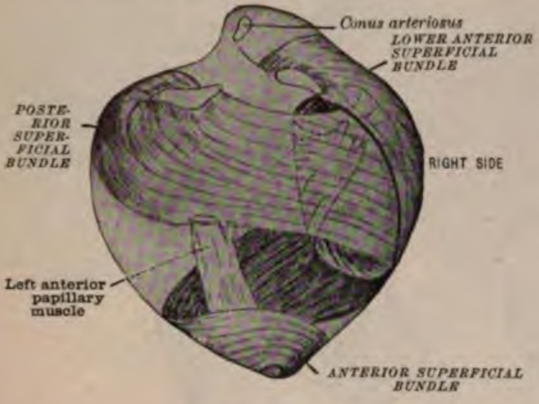

Conus arteriosus
LOWER ANTERIOR SUPERFICIAL BUNDLE
POSTERIOR SUPERFICIAL BUNDLE
RIGHT SIDE
Left anterior papillary muscle
ANTERIOR SUPERFICIAL BUNDLE

FIG. 384.—DIAGRAM OF THE UPPER ANTERIOR SUPERFICIAL BUNDLE SEEN FROM BEHIND. (After MacCallum.)

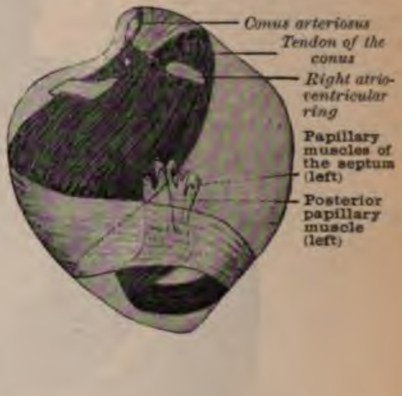
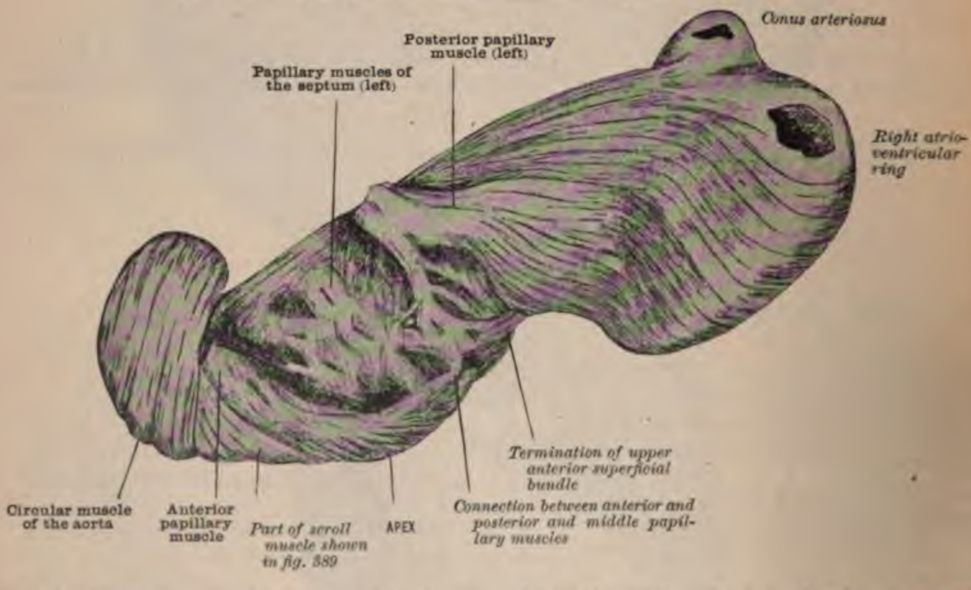

Conus arteriosus
Tendon of the conus
Right atrio-ventricular ring
Papillary muscles of the septum (left)
Posterior papillary muscle (left)

FIG. 385.—THE VENTRICLES UNROLLED. (After MacCallum.)


Conus arteriosus
Posterior papillary muscle (left)
Papillary muscles of the septum (left)
Right atrio-ventricular ring
Termination of upper anterior superficial bundle
Circular muscle of the aorta
Anterior papillary muscle
Part of scroll muscle shown in fig. 389
APEX
Connection between anterior and posterior and middle papillary muscles

The tendons of the muscles of the atria are the atrio-ventricular rings. The muscle bands are in two sets, superficial and deep. The superficial fibres are common to both atria; the deep ones are described as proper to each. The superficial fibres arise and insert in the rings; some of them cross the interatrial septum; others run into it. The deep fibres form two sets, some making loops around each atrium, arising and inserting in the fibrous rings, others forming annular bands around the orifices of the veins and around the fossa ovalis.

FIG. 386.—DIAGRAM OF THE DEEPEST SCROLL LAYER OF THE LEFT VENTRICLE. (After MacCallum.)

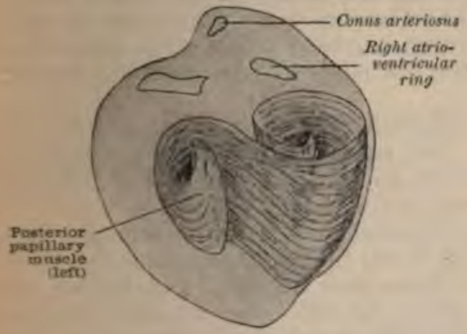

Conus arteriosus
Right atrio-ventricular ring
Posterior papillary muscle (left)

FIG. 387.—DIAGRAM OF THE TWO INNER DEEP SCROLL LAYERS. (After MacCallum.)

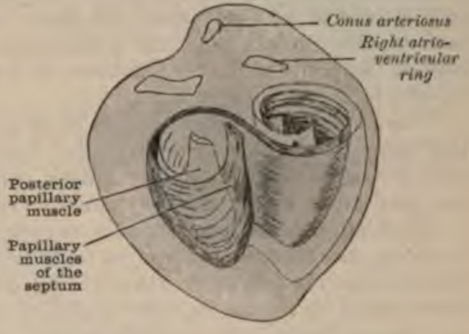

Conus arteriosus
Right atrio-ventricular ring
Posterior papillary muscle
Papillary muscles of the septum

FIG. 388.—DIAGRAM OF THE THREE DEEP SCROLL LAYERS. (After MacCallum.)

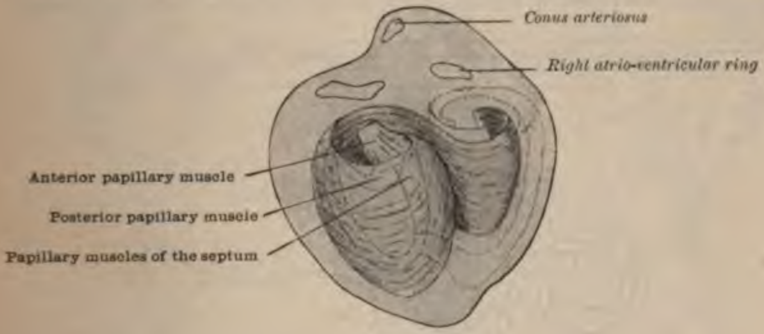

Conus arteriosus
Right atrio-ventricular ring
Anterior papillary muscle
Posterior papillary muscle
Papillary muscles of the septum

FIG. 389.—DIAGRAM OF A FOURTH SCROLL MUSCLE SURROUNDING THE THREE DEEP ONES. (After MacCallum.)

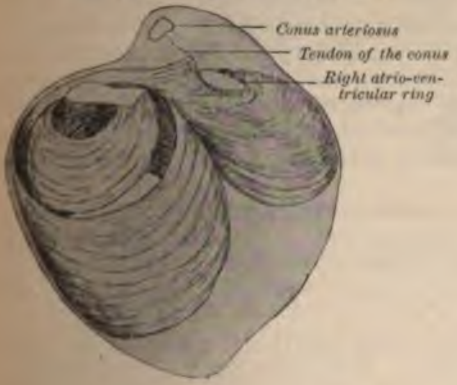
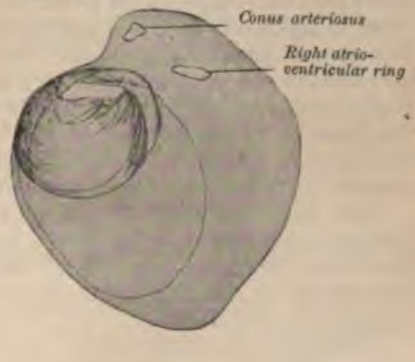

Conus arteriosus
Tendon of the conus
Right atrio-ventricular ring

FIG. 390.—DIAGRAM OF A CIRCULAR MUSCLE AROUND THE ROOT OF THE AORTA AND LEFT ATRIO-VENTRICULAR RING. (After MacCallum.)

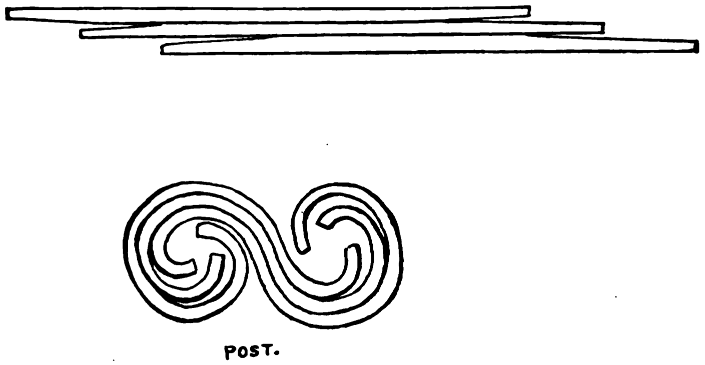

Conus arteriosus
Right atrio-ventricular ring

A much clearer picture of the musculature of the ventricles has been worked out by MacCallum in the developing heart. By beginning with the embryo he was able to unravel the heart and obtain a simple picture of its complex arrangement. Nearly all the fibres are common to both ventricles. The superficial fibres arise in the tendons of the base of one side, pass across the ventricular septum, make a whorl around the apex, and end in the papillary muscles of the opposite side. On the anterior surface of the heart the superficial fibres run diagonally from right to left, and they arise for the most part from the tendon of the conus arteriosus. One band takes origin from the posterior half of the tendon, that is, near the right atrio-ventricular ring, crosses the interventricular groove nearer the apex, and ends in the anterior papillary muscle of the left side (fig. 383). The other band arises from the anterior part of the tendon, near the pulmonary artery, curves over the conus arteriosus, crosses the septum nearer the base, and enters the papillary muscles of the septum on the left side (fig. 384).

The superficial muscles which cross the longitudinal groove on the posterior surface arise from the atrio-ventricular rings. One set arises from the right ring and ends in the posterior papillary muscle of the left side; the other set begins in the left ring and ends in the papillary muscles of the right side (fig. 383).

MacCallum has shown that the deeper fibres, although they seem to belong to each ventricle, are in reality common to both. He found that after removing the superficial layers, the left ventricle could be rolled away from the right; and, indeed, the heart could be almost entirely unrolled, as seen in fig. 385. This is possible because the deeper fibres form a scroll, as seen in fig. 391; that is, they start on one side, curve around that ventricle, then pass in the septum to the opposite surface of the heart and curve around the other ventricle. Both the superficial and the deep fibres cross in the septum—the superficial fibres pass over it, the deep ones pass through it. The deepest band of muscle (fig. 386) begins in the papillary muscles of the right side and ends in the posterior papillary muscle of the left side. Just outside of this layer is a second one which begins in the papillary muscles of the right side and ends in the muscles of the septum of the left. The relative position of these two bands is shown in fig. 387. A third similar bundle is given in fig. 388. It ends in the anterior papillary muscle of the left side.

Fig. 391.—Diagram of the Scroll Layers of the Heart. (After MacCallum.)



Just outside of these deep scroll muscles is another scroll muscle which surrounds them all. It is seen in fig. 389. It arises from the right atrio-ventricular ring and tendon of the conus, passes from the posterior surface of the right ventricle through the septum to the anterior surface of the left ventricle, and ends in the left atrio-ventricular ring.

Besides these bands which are common to both ventricles, there is one band which belongs to the left ventricle alone (fig. 390). It encircles the root of the aorta, and both arises and ends in the left atrio-ventricular ring.

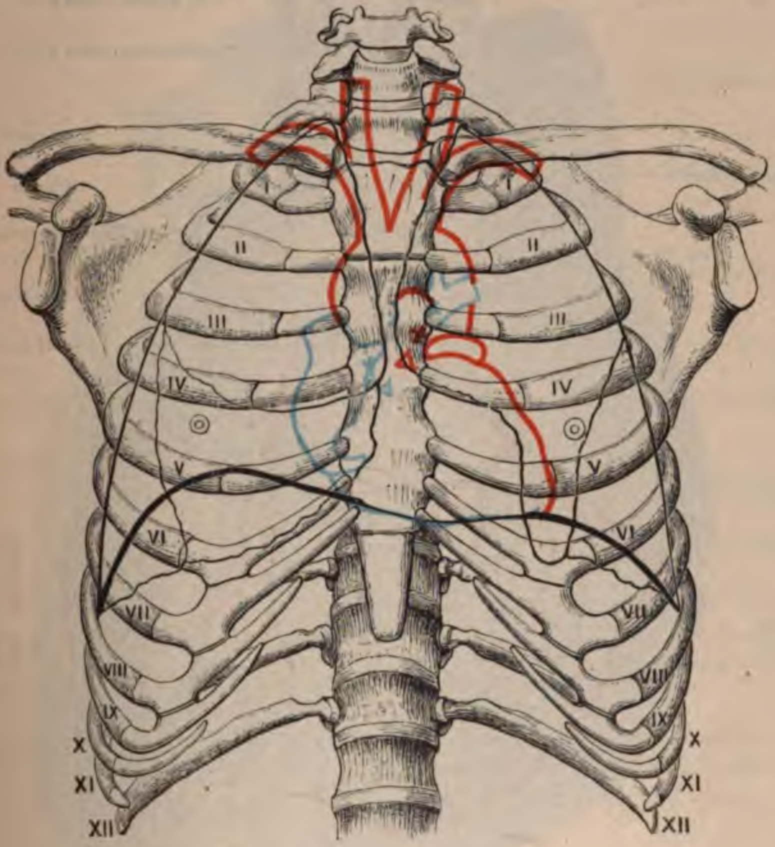
Thus MacCallum has shown that fundamentally the heart may be considered as three flat bands of muscle with a tendon at each end, rolled into a scroll. Thus the fibres which are the most superficial on one side come to be the deepest on the other.

THE RELATION OF THE CHIEF ORIFICES ONE TO THE OTHER AND TO THE CHEST-WALL

The position of the heart varies with the individual, with the position of the body, and with age. It is influenced by the respiratory and cardiac movements, and hence cannot be the same after death. The **tricuspid valve** lies behind the sternum on a level with the fourth interspace and fifth cartilage. The **bicuspid valve** is behind the inner end of the fourth left cartilage and the adjacent part of the sternum. The **orifice of the pulmonary artery** is behind the junction of the third rib with the sternum on the left side, while the **aortic orifice** is behind the lower edge of the third left costal cartilage.

FIG. 392.—SHOWING THE POSITION OF THE HEART AND ITS VALVES IN RELATION TO THE CHEST-WALLS. (Reduced from Hensman and Fisher's Anatomical Outlines.)

(The right atrium and ventricle, and the positions of the pulmonary semilunar and tricuspid valves, are indicated in blue tints; whilst the left atrium and ventricle, with their corresponding valves, are indicated in red.)



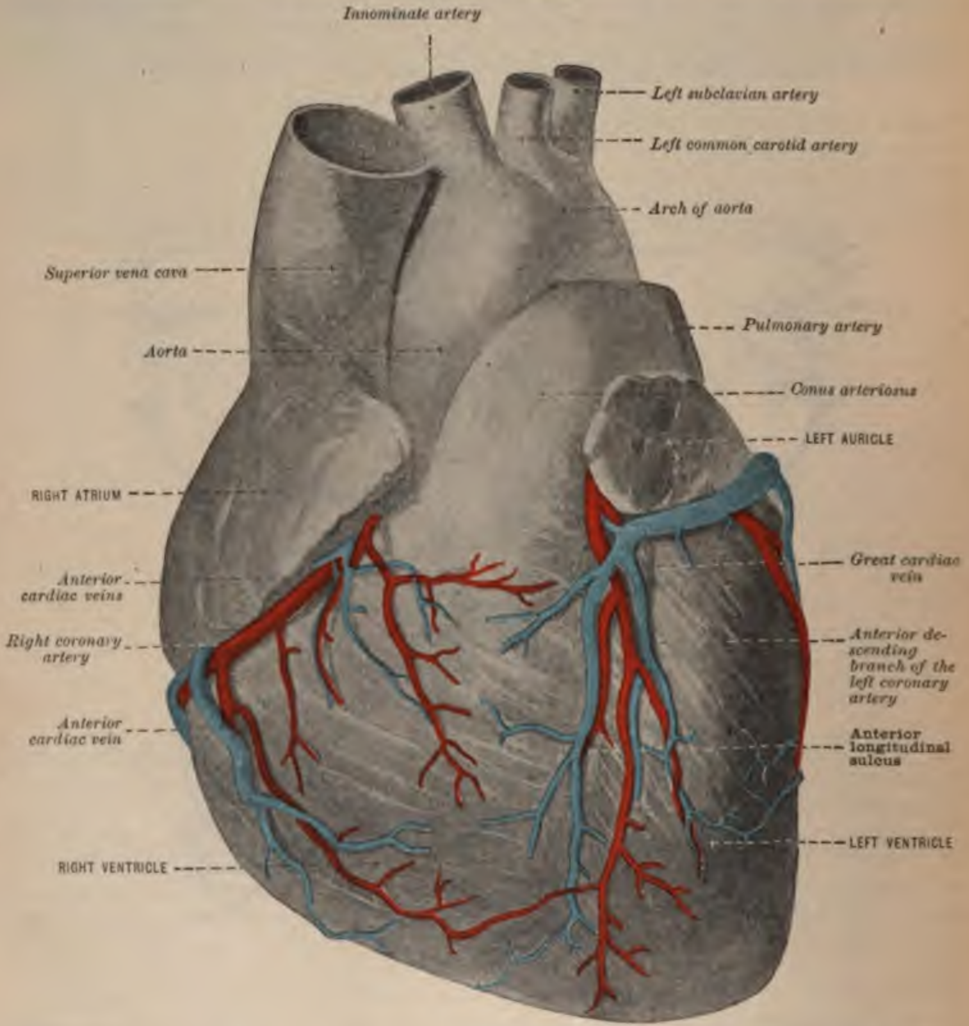
THE VESSELS AND NERVES

The arteries.—The two coronary arteries arise behind the right and left flaps of the aortic semilunar valves.

The **right coronary artery** passes forwards between the pulmonary artery and the right atrium, and then winds in the right coronary sulcus to the posterior surface of the heart (fig. 393). At the commencement of the posterior longitudinal sulcus it divides into its two main branches, one of which passes onwards in the atrio-ventricular groove to anastomose with the left coronary artery, whilst the other, the **posterior descending (interventricular) branch,** passes in the furrow between the ventricles towards the apex, near which it anastomoses with branches derived from the left coronary artery. In this course the right coronary artery supplies branches to the right atrium and roots of the pulmonary artery and aorta, as well as one that descends near the right border of the heart (**right marginal**), and a second (**preventricular**) to the anterior wall of the right ventricle. It supplies both ventricles and the septum.

The **left coronary artery** passes for a short distance forwards, between the pulmonary artery and the left auricle, and then divides into two principal branches, one of which descends in the anterior longitudinal sulcus to the apex of the heart, the **anterior descending (interventricular) branch,** around which it sends branches to anastomose with the right coronary; whilst the other, the **circumflex,** winds to the back of the heart in the coronary groove, to anastomose with the corresponding twigs of the right artery. In this course it gives off a branch which descends near the left border of the heart (**left marginal**) as well as smaller branches to the left atrium, both ventricles, and the commencement of the aorta and pulmonary vessels.

Fig. 393.—Anterior View of the Heart, showing its Arteries and Veins. (After Spalteholz.)


Innominate artery
Left subclavian artery
Left common carotid artery
Arch of aorta
Superior vena cava
Pulmonary artery
Aorta
Conus arteriosus
LEFT AURICLE
RIGHT ATRIUM
Great cardiac vein
Anterior cardiac veins
Right coronary artery
Anterior descending branch of the left coronary artery
Anterior cardiac vein
Anterior longitudinal sulcus
LEFT VENTRICLE
RIGHT VENTRICLE

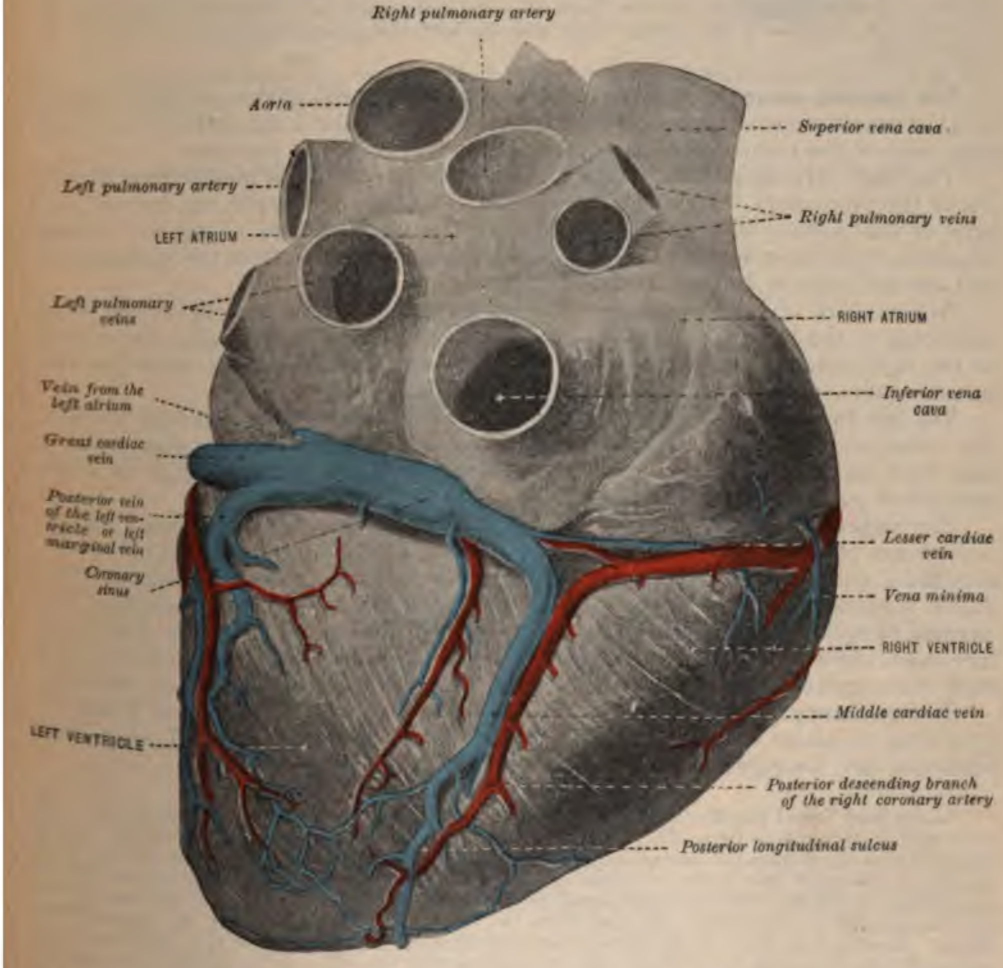
The **cardiac** or **coronary veins** accompany the coronary arteries and return the blood from the walls of the heart.

The **great cardiac vein** (fig. 393) ascends in the anterior longitudinal sulcus, passing round the left side of the heart to its posterior surface in the *coronary sulcus* to terminate in the commencement of the coronary sinus. Its mouth is usually guarded by two valves, and it receives in its course the **left marginal vein,** with other smaller veins from the left atrium and ventricle, all of which are guarded by valves.

The **middle cardiac vein,** sometimes the larger of the two chief veins, communicates with the foregoing at its commencement on the anterior surface above the heart's apex. It ascends in the posterior longitudinal groove, receiving blood from the ventricular walls, and joins the coronary sinus through an orifice guarded by a single valve, close to its termination.

The **posterior vein of the left ventricle** lies upon the posterior surface of the ventricle and, receiving branches from it, passes upwards to terminate either directly in the coronary sinus or else in the great cardiac vein.

FIG. 394.—POSTERIOR VIEW OF THE HEART, SHOWING ITS ARTERIES AND VEINS. (After Spalteholz.)


Right pulmonary artery
Aorta
Superior vena cava
Left pulmonary artery
Right pulmonary veins
LEFT ATRIUM
Left pulmonary veins
RIGHT ATRIUM
Vein from the left atrium
Inferior vena cava
Great cardiac vein
Posterior vein of the left ventricle or left marginal vein
Lesser cardiac vein
Coronary sinus
Vena minima
RIGHT VENTRICLE
Middle cardiac vein
LEFT VENTRICLE
Posterior descending branch of the right coronary artery
Posterior longitudinal sulcus

The **anterior cardiac veins** consist of several small branches from the front of the right ventricle, which vary in number and either open separately into the right atrium or else join the lesser cardiac vein. They also include a **right marginal vein,** which joins the lesser cardiac vein near its termination, or else opens separately into the lower part of the right atrium (fig. 393).

The **lesser cardiac vein** is a small vessel which receives branches from both the right atrium and ventricle, and winds around the right side of the heart, from before backwards, in the coronary sulcus, to terminate in the coronary sinus.

The **coronary sinus** may be regarded as a much dilated terminal portion of the great cardiac vein. It is about 2·5 cm. (1 in.) in length, is covered by muscular fibres from the atrium, and lies in the coronary sulcus on the posterior surface of the heart. Its cardiac orifice, with the coronary (Thebesian) valve, has already been described. Besides the tributary veins already named, a small **oblique vein** of the left atrium may sometimes be traced, on the back of the left atrium, from the vestigial fold to the sinus. This little vein, which is not always pervious or easy of demonstration, never possesses a valve at its orifice, and, like the coronary sinus, formed a part of the left superior vena cava of early fœtal life. The sinus also receives the middle cardiac vein, one or more right atrial branches, and several veins from the back of the left ventricle.

Although anastomoses occur between the two coronary arteries, these are by no means extensive, and are not sufficient to allow of the establishment of a satisfactory collateral circulation in the case of the blocking of one coronary artery. Consequently such interferences with the cardiac circulation produce rapid pathological changes in the heart musculature, provided they are sudden in occurrence. If the obliteration of the artery take place gradually, however, some relief may be afforded by the establishment of a collateral circulation through the venæ minimæ, which open out from both the atrial and ventricular cavities and communicate with the finer branches of the cardiac veins, and also with the general capillary network in the heart's walls.

The **cardiac nerves,** derived from the vagus and the cervical sympathetic, descend into the superior mediastinum, passing in front of and behind the arch of the aorta; they unite in the formation of the superficial and deep cardiac plexuses.

The **deep cardiac plexus,** the larger and more important, is placed immediately above the pulmonary artery at its point of division, lying between the trachea and arch of the aorta. It is usually formed by the interlacement of all the cardiac branches, with the exception of the left superior cardiac branch from the sympathetic and the left inferior cardiac from the vagus.

A meshwork of branches descends from the plexus, some passing to the right and some to the left. The greater number of the right branches follow the course of the right coronary artery to form the right coronary plexus, but some join the anterior pulmonary plexus and others go to the right atrium.

The left branches, which are both larger and more numerous, descend beneath the corresponding pulmonary artery to join the left coronary plexus; some of these pass right and left to join the anterior pulmonary plexuses at the roots of the lungs and others join the superficial plexus.

The **superficial cardiac plexus,** which lies above the right pulmonary artery as it passes beneath the arch of the aorta, is formed by the interlacement of the left superficial cardiac branch from the sympathetic, and the inferior cardiac from the vagus, together with branches derived from the deep plexus. A small ganglion, the **cardiac ganglion of Wrisberg,** is sometimes found close to the right side of the ligamentum arteriosum. The greater number of the filaments from this plexus go to the right coronary plexus. Some, however, reach the left anterior pulmonary plexus.

The **coronary plexuses** follow the course of the vessels, and their filaments enter the muscular walls of the heart. Minute ganglia are connected with these filaments, and are especially abundant near the coronary groove.

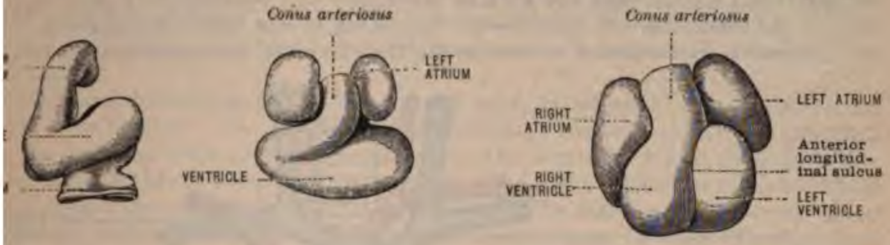
It has been found that the impulses conveyed to the heart by means of these various ner serve merely to regulate its action; they are not the primary causes of the heart-beat. Th impulses that come from the central nervous system by way of the vagus serve to diminish t rapidity of the heart-beat or even to arrest it, and the fibres conveying such impulses are term the **inhibitory fibres.** On the other hand, the impulses conveyed by the sympathetic nerv tend to quicken the heart-beat, and the fibres by which they pass are known as **accelerat fibres.** Besides these there are also fibres which pass from the heart by way of the vagus branc to the medulla oblongata, where they come into relation with vaso-dilator fibres, whereby impul arising in the heart itself reflexly produce a dilatation of the peripheral blood-vessels, th diminishing the blood pressure and lessening the work of the heart. These fibres passing fr the heart are known as the **depressor fibres.**

The right atrium of the heart receives its blood from both venæ cavæ, as well from the coronary sinus. That which is conveyed by the superior cava is veno blood returned from the head and neck and upper extremities. The inferior ca returns the blood from the lower half of the body, and in fœtal life that which con from the placenta through the umbilical vein. This latter stream reaches the infer cava, in part directly through the ductus venosus, and in part through the liver a hepatic veins.

THE FŒTAL CIRCULATION

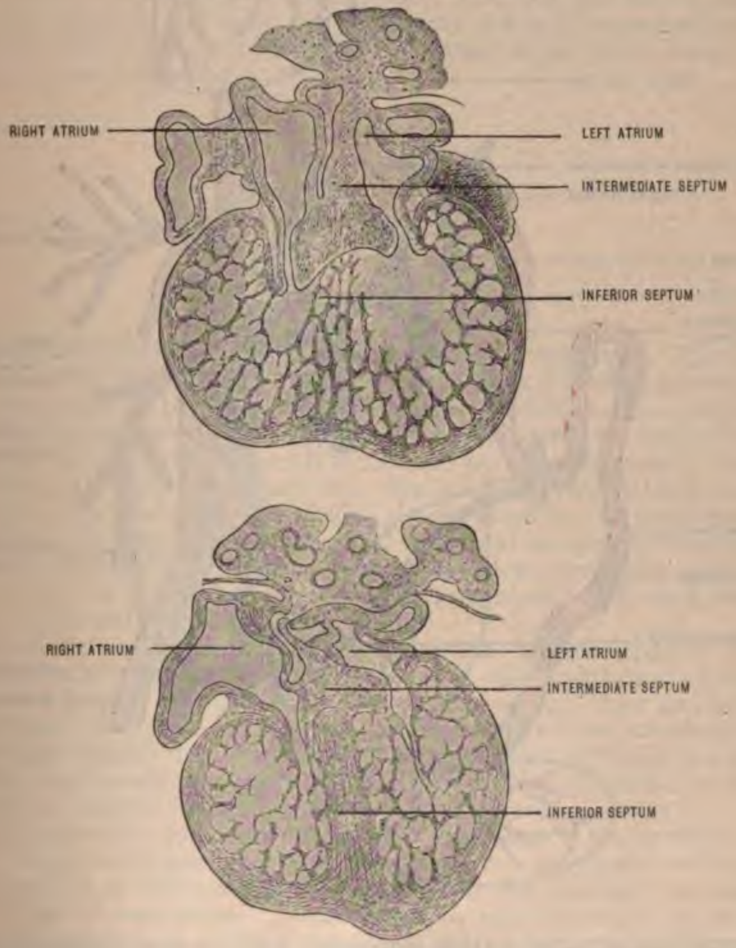
fœtal circulation is best understood by a study of the development of the His has shown that the heart begins as a simple tube bent in the form of an

ig. 395.—Models showing the Development of the Heart. (After His.)


Conus arteriosus
LEFT ATRIUM
VENTRICLE
Conus arteriosus
RIGHT ATRIUM
RIGHT VENTRICLE
LEFT ATRIUM
Anterior longitudinal sulcus
LEFT VENTRICLE

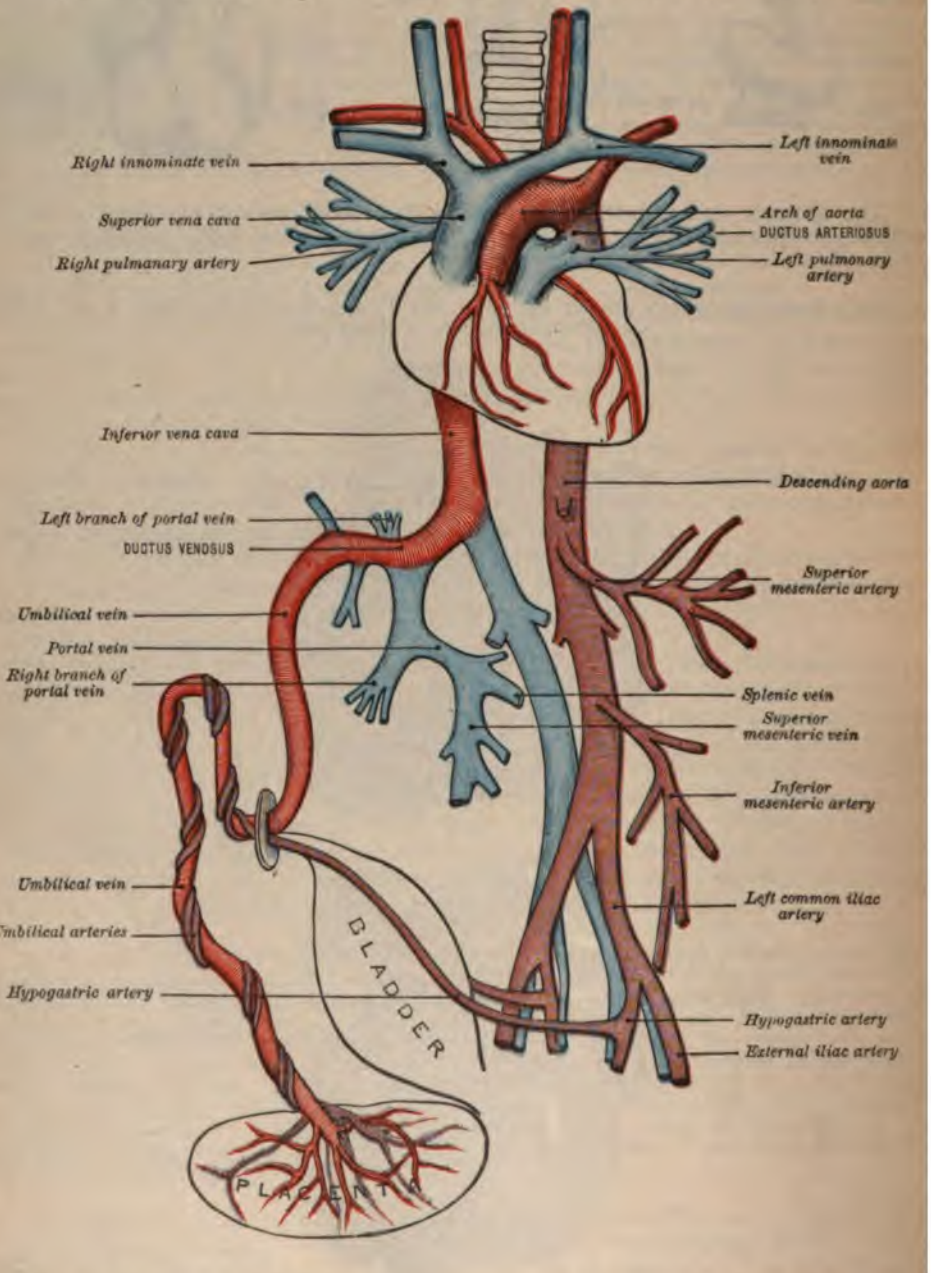
e anterior end is arterial and sends the blood towards the head, while the posterior end is venous. Owing to the curve of the tube, the heart can be

.—Sections of the Heart showing the Formation of the Septum and Atrio-ventricular Valves. (After His.)


RIGHT ATRIUM
LEFT ATRIUM
INTERMEDIATE SEPTUM
INFERIOR SEPTUM
RIGHT ATRIUM
LEFT ATRIUM
INTERMEDIATE SEPTUM
INFERIOR SEPTUM

d into three portions, the atrium, ventricle, and bulbus arteriosus. From ent tube with a single continuous chamber developes the adult heart with four chambers. The atria develope as saccular lateral outgrowths from the primitive atrium; they remain in communication up to the time of birth, but Born has shown that the primitive opening closes and a secondary one, the foramen ovale, is formed. In the third stage the longitudinal sulcus which marks the division of the right and left heart appears. As seen on the inside, this separation is somewhat

FIG. 397.—THE HEART, WITH THE ARCH OF THE AORTA, THE PULMONARY ARTERY, THE DUCTU ARTERIOSUS, AND THE VESSELS CONCERNED IN THE FŒTAL CIRCULATION.
(From a preparation of a fœtus in the Museum of St. Bartholomew's Hospital.)


Right innominate vein
Superior vena cava
Right pulmonary artery
Left innominat vein
Arch of aorta
DUCTUS ARTERIOSUS
Left pulmonary artery
Inferior vena cava
Descending aorta
Left branch of portal vein
DUCTUS VENOSUS
Superior mesenteric artery
Umbilical vein
Portal vein
Right branch of portal vein
Splenic vein
Superior mesenteric vein
Inferior mesenteric artery
Umbilical vein
Left common iliac artery
Umbilical arteries
BLADDER
Hypogastric artery
Hypogastric artery
External iliac artery
PLACENTA

complicated, and is made by three structures: first, the chief inferior septum, which is made of muscle and grows from the apex of the primitively single ventricle; second the aortic septum, which is a fold of connective tissue that separates the primitiv bulbus arteriosus into pulmonary artery and aorta; and, third, an intermediat septum, which grows from the wall of the primitive atrium. These three parts fuse to make the main septum.

At the venous end of the heart in early embryos the great veins unite into a sac, the sinus reuniens, which in turn passes into the atrium. This sinus reuniens receives the superior and inferior venæ cavæ and the coronary sinus, and it is marked off from the atrium even in the adult heart (fig. 371). Since the bulbus arteriosus, which is divided longitudinally by the aortic septum, is a portion of the primitive heart, the proximal portions of the aorta and pulmonary artery, which are formed from it, are also primarily portions of the heart, and, hence, are invested by the pericardium.

After the four chambers of the heart have been established, the course of the circulation is as follows: The oxygenated blood enters the fœtus from the placenta through the umbilical vein, a part of it passing to the liver, and a part directly to the inferior vena cava through the ductus venosus. The right atrium receives its blood from both venæ cavæ and from the coronary sinus. The inferior cava returns blood from the lower half of the body, as well as from the placenta through the umbilical vein. This latter stream comes in part through the ductus venosus, and in part through the liver. On entering the atrium the blood from the inferior vena cava is directed by the Eustachian valve through the foramen ovale into the left atrium. From there it passes into the left ventricle, and thence through the aorta to the head, neck, and upper extremities. A part passes into the descending aorta.

The impure blood from the head and neck enters the right atrium through the superior vena cava. This stream crosses in front of that from the inferior cava and enters the right ventricle, and since the pulmonary artery is connected with the aorta by means of the ductus arteriosus (fig. 397), most of this blood passes, not to the lungs, but to the descending aorta.

THE ARTERIES

The **arteries** are divided into the **pulmonary** and the **systemic.** The pulmonary convey the blood from the right ventricle of the heart to the lungs, whence it is returned, when aërated, by the pulmonary veins to the left atrium, and through that cavity into the left ventricle. The systemic arteries carry the blood from the left ventricle all over the body, whence it is returned by the venæ cavæ to the right atrium, and through it to the right ventricle. The lungs also receive blood from the systemic arteries—the bronchial. This blood, which serves for the nourishment of the larger and smaller braches of the bronchial tubes and the lung substance, is returned, in part by the bronchial veins to the general venous circulation, and thence to the right side of the heart, and in part by the pulmonary veins, along with the aërated blood, to the left side of the heart.

As a rule, the mode of branching of the arteries is dendritic; that is to say, they give off finer and finer branches at an acute angle, and the diameter of the sum of these branches exceeds the diameter of the original stem. There are, however, several exceptions to this mode, as, for example, **recurrent** arteries, which are often fine branches much smaller than the original stem, that carry the blood in a reverse direction. The **vasa vasorum,** which run in the adventitia of the larger vessels, are often recurrent arteries from a branch of the larger one.

The various **anastomoses** of arteries are also exceptions to the dendritic mode of branching. By anastomoses are meant the opening into one another of branches either of the same or of different arteries. The nearer the capillary network, the greater the number of anastomoses. Anastomoses are either simple or in the form of a network. The simple ones are the arches made between two fairly large branches, and in these it seems as if two opposing streams of blood must meet, as, for example, in the arteries of the lips. In certain cases branches are given off from the arch, as, for example, from the palmar arch, or from the loops of the intestinal arteries.

Anastomoses in the form of a network are more frequent. Each joint is surrounded by a network of branches derived both from descending and from recurrent branches. In the various organs the anastomosing network is the rule, and an artery which splits into an isolated network is known as a **terminal artery.** The sudden breaking up of an artery into a network of fine branches is known as a **rete mirabile,** the glomerulus of the kidney representing such a structure in the human body. By means of these various types of anastomoses it is clear that the interruption of a single branch is less harmful to the organism; that is to say, they are a kind of insurance against injury, and they must also serve to break the force of the blood-stream. A study of anastomoses has a further interest in that they often serve to explain variations, for in case of an unusually large anastomosis the main stream of blood may take a course that would otherwise be a side branch.

Variations.—One of the important parts of the study of the vascular system consists in a knowledge of variations, for while many of them cause no disturbance in the functions of the body, they may be of great importance to the surgeon. Others, however, are compatible only with intrauterine life, and so cause death at birth. Variations may represent persistent fœtal forms of the circulation, and in this connection the recent studies of Mall and others on the wandering of blood-vessels in the course of their development threw much light on variations. Secondly, they may represent a recurrence to some of the forms found in the lower animals. A third group represents individual variations, certain of which may be explained, as already stated, by a study of the usual anastomoses. Variations may be rare, or so common as to make it difficult to determine the normal, certain arteries being fairly constant, others extremely variable.

THE PULMONARY ARTERY

The **pulmonary artery** (fig. 398) passes from the right ventricle to the lungs. It differs from all other arteries in the body in that it contains venous blood. It arises as a short, thick trunk from the upper and front part of the right ventricle, known as the **conus arteriosus,** and, after a course of about 5 cm. (2 in.) within the pericardium—the serous layer of which membrane forms a common sheath for it and the aorta—divides into a right and a left branch. These branches pierce the pericardium, and pass to the right and left lung respectively.

The **trunk of the pulmonary artery** at its origin is on a plane anterior to the first portion of the arch of the aorta, and slightly overlaps that vessel. Thence it passes upwards, backwards, and to the left, forming a slight curve around the front and left side of the ascending portion of the aorta; and, having reached the concavity of the transverse portion of the aortic arch, on a level with the fifth thoracic vertebra, and on a plane posterior to the ascending aorta, it divides into its right and left branches, which diverge from each other at an angle of about 130°.

In the fœtus, the pulmonary artery continues its course upwards, backwards, and to the left, under the name of the **ductus arteriosus (Botalli),** and opens into the descending aorta just below the origin of the left subclavian artery (fig. 397). After birth, that portion of the pulmonary artery which extends to the aorta becomes obliterated, and remains merely as a fibrous cord, the **ligamentum arteriosum.**

The trunk of the artery with the ductus arteriosus was originally the left fifth aortic arch, and the recurrent laryngeal nerve in early fœtal life passed below it direct to the larynx. As in the process of development the heart descends into the thorax, and the fifth arch assumes a more vertical direction, it comes to pass that the nerve winds round the transverse portion of the aorta, the fourth aortic arch, and consequently is external to the ductus arteriosus (fig. 401). In adult life the cor formed by the obliterated ductus arteriosus arises a little to the left of the bifurc tion of the pulmonary artery, and receives a slight reflexion from the pericardiu as it pierces that membrane. It occasionally remains partially unobliterated.

Relations.—**In front,** the trunk of the pulmonary artery is covered by the seco bone of the sternum, the remains of the thymus gland, and the pericardium, a at its commencement lies immediately behind the anterior extremity of the seco intercostal space, the left lung and pleura intervening.

Behind, it lies successively upon the ascending part of the arch of the aorta and the left atrium.

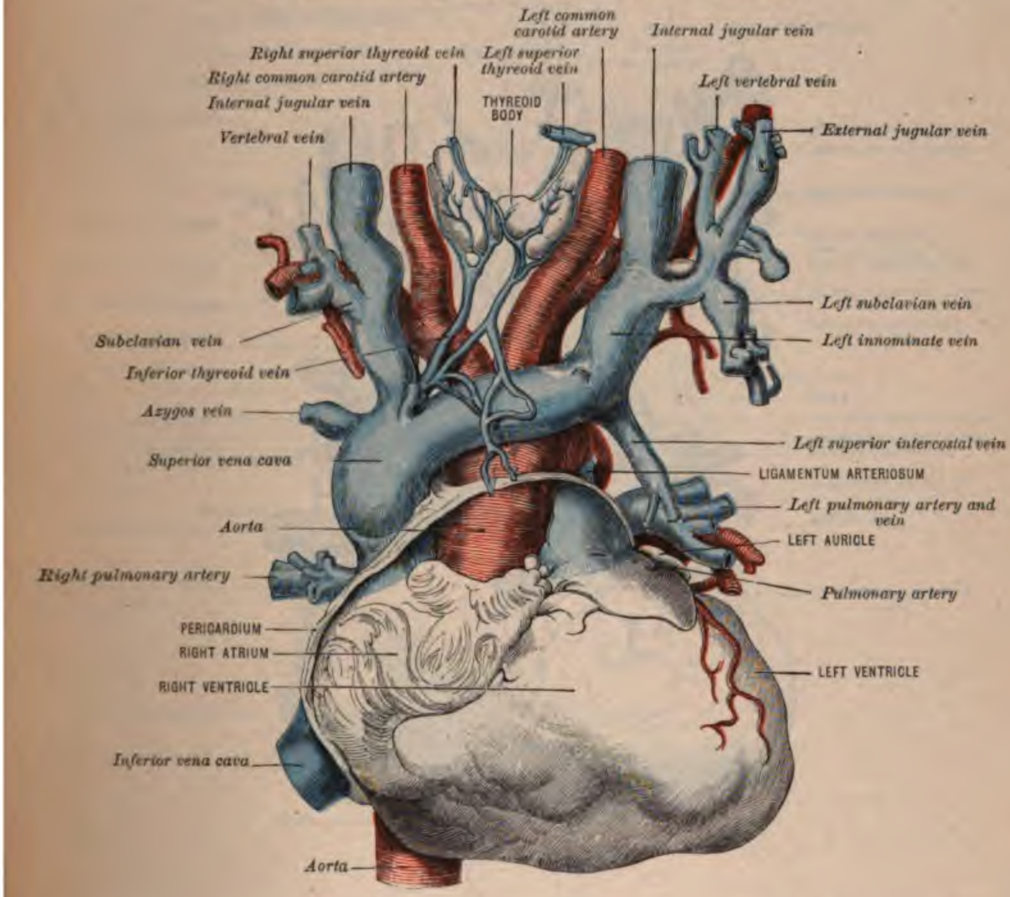
To the **right** are the ascending aorta, the right auricle, the right coronary artery, and the cardiac nerves.

To the **left** are the pericardium, the left pleura and lung, the left auricle, the left coronary artery, and the cardiac nerves.

THE RIGHT PULMONARY ARTERY

The **right pulmonary artery,** longer than the left, passes almost horizontally outwards under the arch of the aorta to the root of the right lung, where it divides, either directly or after repeated division, into three branches, one for each lobe. These branches follow the course of the bronchi, dividing and subdividing for the supply of the lobules of the lung. The terminal branches do not anastomose with each other.

FIG. 398.—ANTERIOR VIEW OF THE HEART WITH THE LARGE ARTERIES AND VEINS. (By permission. Royal College of Surgeons Museum.)


Left common carotid artery
Internal jugular vein
Right superior thyreoid vein
Left superior thyreoid vein
Right common carotid artery
Left vertebral vein
Internal jugular vein
THYREOID BODY
External jugular vein
Vertebral vein
Left subclavian vein
Subclavian vein
Left innominate vein
Inferior thyreoid vein
Azygos vein
Left superior intercostal vein
Superior vena cava
LIGAMENTUM ARTERIOSUM
Left pulmonary artery and vein
Aorta
LEFT AURICLE
Right pulmonary artery
Pulmonary artery
PERICARDIUM
RIGHT ATRIUM
LEFT VENTRICLE
RIGHT VENTRICLE
Inferior vena cava
Aorta

Relations.—In its course to the lung it has **in front** of it the ascending aorta, the superior vena cava, the phrenic nerve, the anterior pulmonary plexus, and the reflexion of the pleura. **Behind** are the right bronchus and the termination of the azygos vein. **Above** is the transverse portion of the arch of the aorta, and **below** are the left atrium and the upper right pulmonary vein.

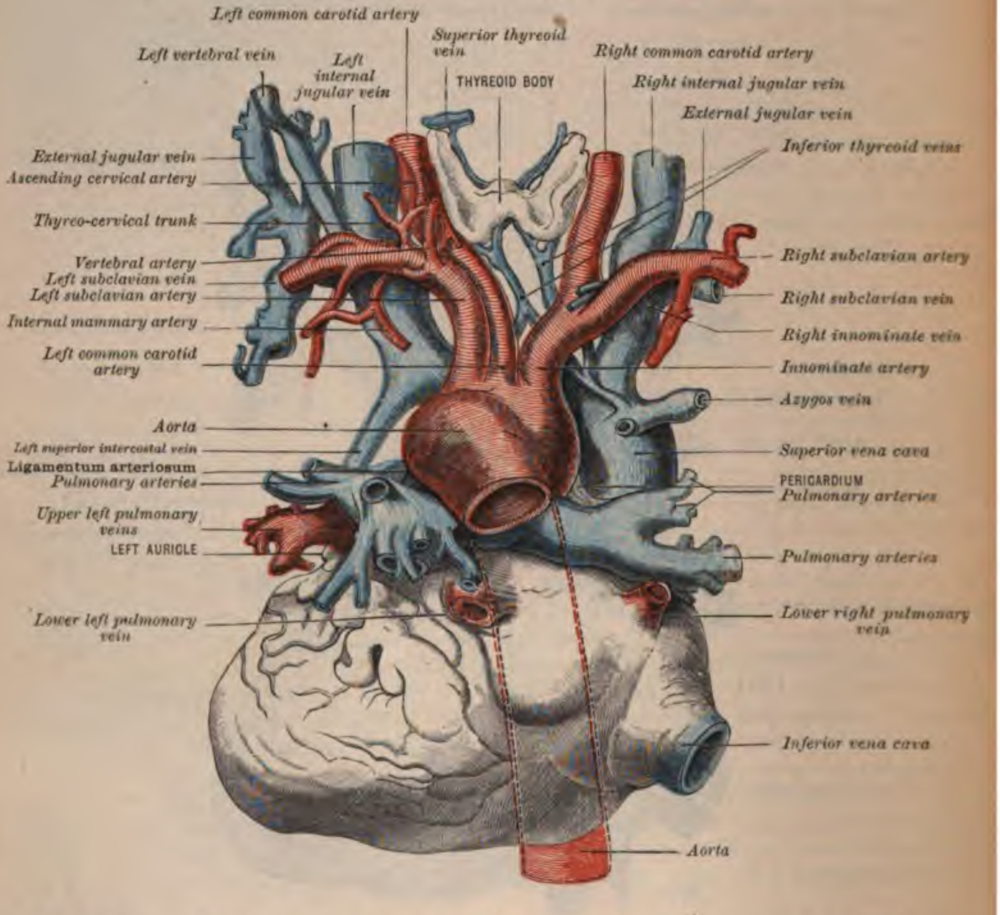
At the root of the lung it has the right bronchus **above** and **behind** it; the pulmonary veins **below** and in **front.** Crossing in front of it and the other structures forming the root of the lung are the phrenic nerve and the anterior pulmonary plexus; behind are the azygos vein, the vagus nerve, and the posterior pulmonary plexus.

THE LEFT PULMONARY ARTERY

The **left pulmonary artery,** shorter and slightly smaller than the right, passes in front of the descending aorta to the root of the left lung, where it divides into two branches for the supply of the upper and lower lobes respectively. These divide and subdivide as on the right side.

Fig. 399.—Posterior View of Heart and Greater Vessels.

(By permission. Royal College of Surgeons Museum.)


Left common carotid artery
Left vertebral vein
Left internal jugular vein
Superior thyreoid vein
THYREOID BODY
Right common carotid artery
Right internal jugular vein
External jugular vein
Inferior thyreoid veins
External jugular vein
Ascending cervical artery
Thyreo-cervical trunk
Vertebral artery
Left subclavian vein
Left subclavian artery
Internal mammary artery
Left common carotid artery
Right subclavian artery
Right subclavian vein
Right innominate vein
Innominate artery
Azygos vein
Aorta
Left superior intercostal vein
Ligamentum arteriosum
Pulmonary arteries
Upper left pulmonary veins
LEFT AURICLE
Superior vena cava
PERICARDIUM
Pulmonary arteries
Pulmonary arteries
Lower left pulmonary vein
Lower right pulmonary vein
Inferior vena cava
Aorta

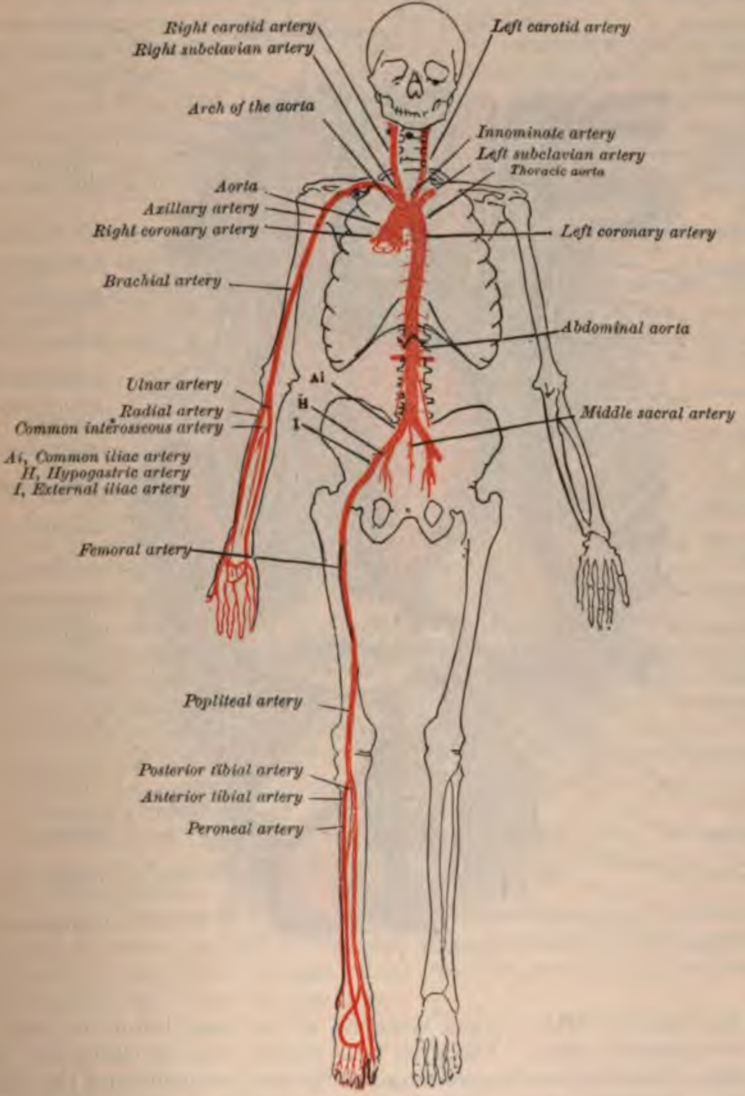
Relations.—At the root of the lung it has the left bronchus **behind** and also **below** it, in consequence of the more vertical direction taken by the left bronchus than by the right. **Below** and **in front** are the pulmonary veins, while between the artery and the upper left pulmonary vein the vestigial fold of pericardium is to be seen. Crossing in front of it and the other structures forming the root of the lung are the phrenic nerve, the anterior pulmonary plexus, and the reflexion of the left pleura; crossing behind, are the descending aorta, the left vagus nerve, and the posterior pulmonary plexus.

THE SYSTEMIC ARTERIES

THE AORTA

The **aorta** is the main systemic arterial trunk, and from it all the systemic arteries are derived. It begins at the left ventricle of the heart, and, after running a short distance upwards and to the right, turns backwards and to the left, and then downwards, forming the **arch of the aorta.** It is thence continued through the thorax as the **thoracic aorta,** and finally enters the abdomen at the aortic opening in the diaphragm, and, passing through the abdominal cavity under the name of the **abdominal aorta,** terminates opposite the fourth lumbar vertebra in the right and left common iliac arteries. From the point of bifurcation a small vessel is continued down the middle line in front of the sacrum and coccyx, and ends in the coccygeal glomerulus. This vessel (known as the **middle sacral**) is usually regarded, morphologically, as the **sacral** and **coccygeal aorta.**

FIG. 400.—SCHEME OF THE SYSTEMIC CIRCULATION. (After Henle.)

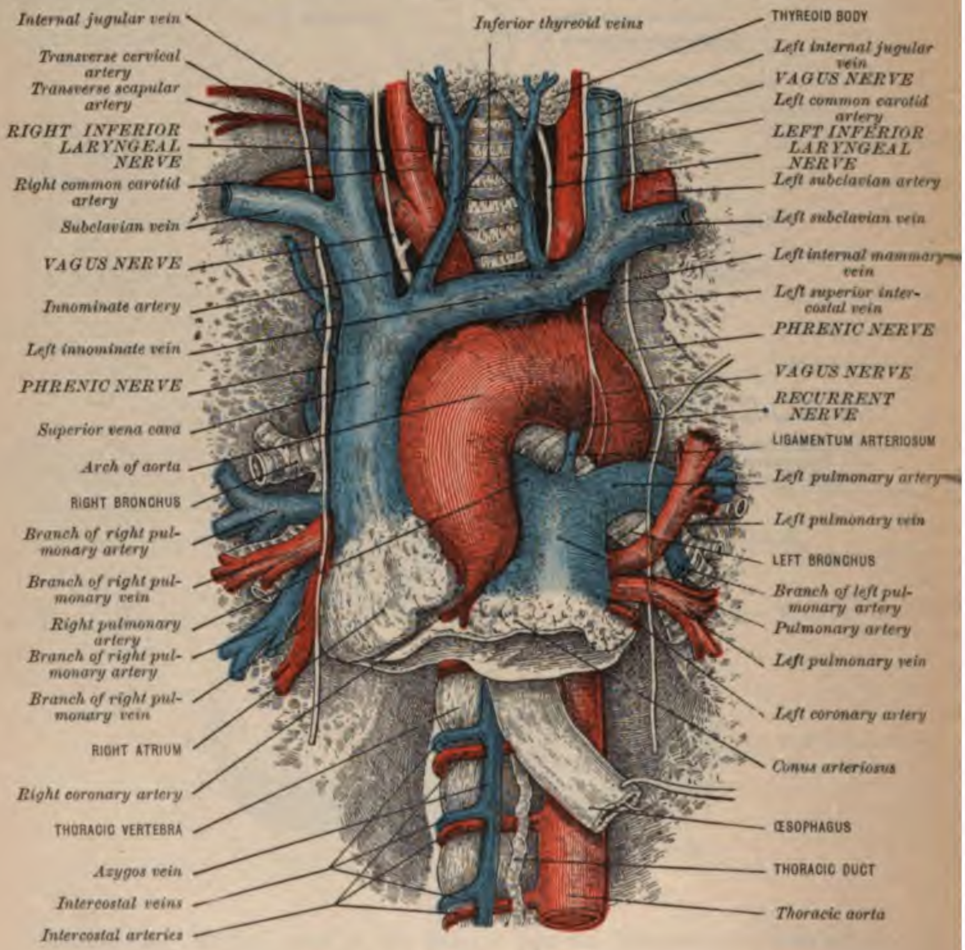

Right carotid artery
Right subclavian artery
Arch of the aorta
Aorta
Axillary artery
Right coronary artery
Brachial artery
Ulnar artery
Radial artery
Common interosseous artery
Ai, Common iliac artery
H, Hypogastric artery
I, External iliac artery
Femoral artery
Popliteal artery
Posterior tibial artery
Anterior tibial artery
Peroneal artery
Left carotid artery
Innominate artery
Left subclavian artery
Thoracic aorta
Left coronary artery
Abdominal aorta
Middle sacral artery
Ai
H
I

THE ARCH OF THE AORTA

The **arch of the aorta** (fig. 401) begins at the upper and back part of the left ventricle of the heart, behind the sternum, on a level with the lower border of the third left costal cartilage. Thence it passes upwards and slightly forwards and to the right, as high as the level of the upper border of the second costal cartilage of the right side; and then, curving backwards, upwards, and to the left, crosses behind the sternum at the level of the middle of the manubrium; and, reaching the left side of the body of the fourth thoracic vertebra, runs downwards on the side of the body of that and the fifth thoracic vertebra, at the lower border of which it terminates in the thoracic aorta. The arch thus formed has its convexity upwards and to the right; in its concavity are situated the left bronchus and the right pulmonary artery. According to its direction, it is somewhat arbitrarily divided into an ascending, transverse, and descending part. Morphologically, the ascending portion is the ventral aorta; the descending portion, part of the left dorsal aorta; and the transverse portion, the fourth left aortic arch. Each portion requires a separate description.

FIG. 401.—THE ARCH OF THE AORTA, WITH THE PULMONARY ARTERY AND CHIEF BRANCHES OF THE AORTA.

(Modified from a dissection in St. Bartholomew's Hospital Museum.)


Internal jugular vein
Transverse cervical artery
Transverse scapular artery
RIGHT INFERIOR LARYNGEAL NERVE
Right common carotid artery
Subclavian vein
VAGUS NERVE
Innominate artery
Left innominate vein
PHRENIC NERVE
Superior vena cava
Arch of aorta
RIGHT BRONCHUS
Branch of right pulmonary artery
Branch of right pulmonary vein
Right pulmonary artery
Branch of right pulmonary artery
Branch of right pulmonary vein
RIGHT ATRIUM
Right coronary artery
THORACIC VERTEBRA
Azygos vein
Intercostal veins
Intercostal arteries
Inferior thyreoid veins
THYREOID BODY
Left internal jugular vein
VAGUS NERVE
Left common carotid artery
LEFT INFERIOR LARYNGEAL NERVE
Left subclavian artery
Left subclavian vein
Left internal mammary vein
Left superior intercostal vein
PHRENIC NERVE
VAGUS NERVE
RECURRENT NERVE
LIGAMENTUM ARTERIOSUM
Left pulmonary artery
Left pulmonary vein
LEFT BRONCHUS
Branch of left pulmonary artery
Pulmonary artery
Left pulmonary vein
Left coronary artery
Conus arteriosus
ŒSOPHAGUS
THORACIC DUCT
Thoracic aorta

The Ascending Portion of the Arch of the Aorta

The **ascending portion** or ventral aorta ascends behind the sternum from the upper part of the left ventricle of the heart, on a level with the lower border of the third left costal cartilage, to the upper border of the second right costal cartilage at the junction of these cartilages with the sternum. It measures about 5 to 5·5 cm. (2 to 2¼ in.), forming, as it ascends, a gentle curve, the most prominent part of which, when the aorta is distended, is situated about 6 mm. (¼ in.) from the sternum. It is enclosed for the greater part of its length in the pericardium, being invested, together with the pulmonary artery, in a common sheath formed by the serous layer of that membrane. A dilatation known as the great sinus of the arch of the aorta is often present along the right side. Immediately above the heart the aorta presents three bulgings, known as the **aortic sinuses** (sinuses of Valsalva); they are placed, one to the right, one to the left, and one posteriorly. From the right and left are derived the coronary arteries of the heart. (See Heart.)

Relations.—In front, it is overlapped at its commencement by the right auricle and the pulmonary artery. Higher up, as the pulmonary artery and auricle diverge, it is separated from the manubrium by the pericardium, the remains of the thymus gland, and by the loose tissue and fat in the superior mediastinum, and is here slightly overlapped by the right pleura and by the edge of the right lung in full inspiration. The commencement of the coronary arteries is also in front.

Behind are the left atrium of the heart, the right pulmonary artery, the right bronchus, and the anterior right deep cardiac nerves.

On the **right side** it is in contact, below with the right atrium, and above with the superior vena cava.

On the **left side** are the pulmonary artery and the branches of the right superficial nerves.

The Transverse Portion of the Arch of the Aorta

The transverse portion of the arch of the aorta extends in a gentle curve upwards, backwards, and to the left, from the level of the upper border of the second right costal cartilage to the left side of the body of the fourth thoracic vertebra. Passing under the arch are the left bronchus, the right pulmonary artery, and the left recurrent (laryngeal) nerve. It measures about 4·5 cm. (1¾ in.).

Relations.—In front, it is slightly overlapped by the right pleura and lung, and to a greater extent by the left pleura and lung. It is crossed in the following order from right to left, by the phrenic nerve, by the cardiac branches of the vagus nerve, the cardiac branches of the sympathetic nerve, by the vagus nerve, and by the left superior intercostal vein as it passes up to the left innominate vein.

Behind it are the trachea, the œsophagus, the thoracic duct, the deep cardiac plexus which is situated on the trachea just above its bifurcation, and the left recurrent (laryngeal) nerve.

Above it are the three chief branches for the head, neck, and upper extremities, namely, the innominate, the left carotid, and the left subclavian arteries, and the left innominate vein.

Below it—that is, in its concavity—are the bifurcation of the pulmonary artery, the left bronchus, the left recurrent (laryngeal) nerve, the remains of the ductus arteriosus, the superficial cardiac plexus, two or more bronchial lymphatic glands, and the reflexion of the pericardium.

The Descending Portion of the Arch of the Aorta

The descending portion of the arch of the aorta, morphologically a part of the primitive dorsal aorta, descends by the left side of the body of the fourth and fifth thoracic vertebræ, and ends at the lower border of the latter in the thoracic aorta.

Just below the spot where the ligamentum arteriosum (the fifth left arch) joins the aorta a constriction (the **aortic isthmus**) is at times met with, and below this again a dilatation of a fusiform shape (the **aortic spindle**).

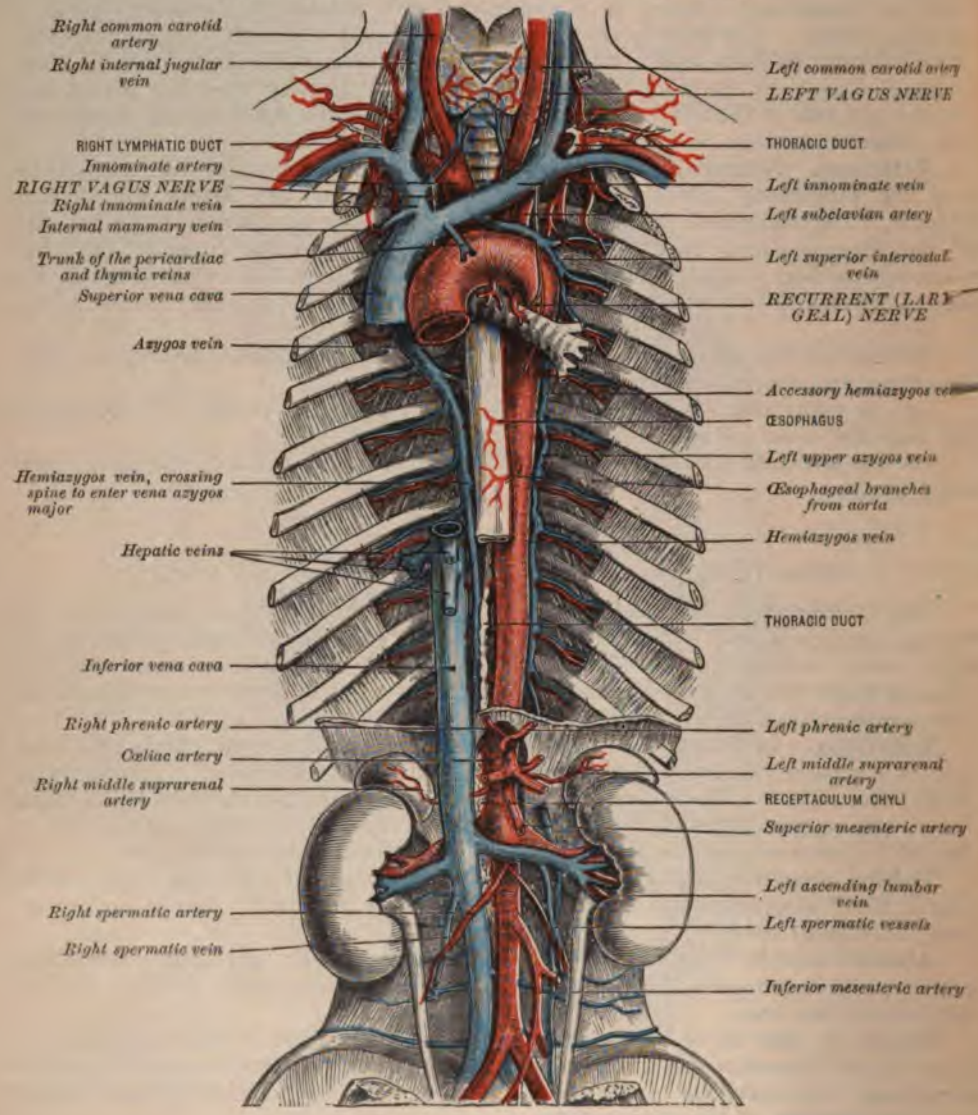
Relations.—**In front,** it is in contact with the reflexion of the left pleura and the root of the left lung.

Behind, it is in relation with the left side of the bodies of the fourth and fifth thoracic vertebræ and the pleura.

To the **right side** are the œsophagus and thoracic duct, and the fourth and fifth thoracic vertebræ.

To the **left side** are the left pleura and lung.

FIG. 402.—THE THORACIC AND ABDOMINAL AORTA.


Right common carotid artery
Right internal jugular vein
RIGHT LYMPHATIC DUCT
Innominate artery
RIGHT VAGUS NERVE
Right innominate vein
Internal mammary vein
Trunk of the pericardiac and thymic veins
Superior vena cava
Azygos vein
Hemiazygos vein, crossing spine to enter vena azygos major
Hepatic veins
Inferior vena cava
Right phrenic artery
Cœliac artery
Right middle suprarenal artery
Right spermatic artery
Right spermatic vein
Left common carotid artery
LEFT VAGUS NERVE
THORACIC DUCT
Left innominate vein
Left subclavian artery
Left superior intercostal vein
RECURRENT (LARY GEAL) NERVE
Accessory hemiazygos ve
ŒSOPHAGUS
Left upper azygos vein
Œsophageal branches from aorta
Hemiazygos vein
THORACIC DUCT
Left phrenic artery
Left middle suprarenal artery
RECEPTACULUM CHYLI
Superior mesenteric artery
Left ascending lumbar vein
Left spermatic vessels
Inferior mesenteric artery

The Development of the Aortic Arch

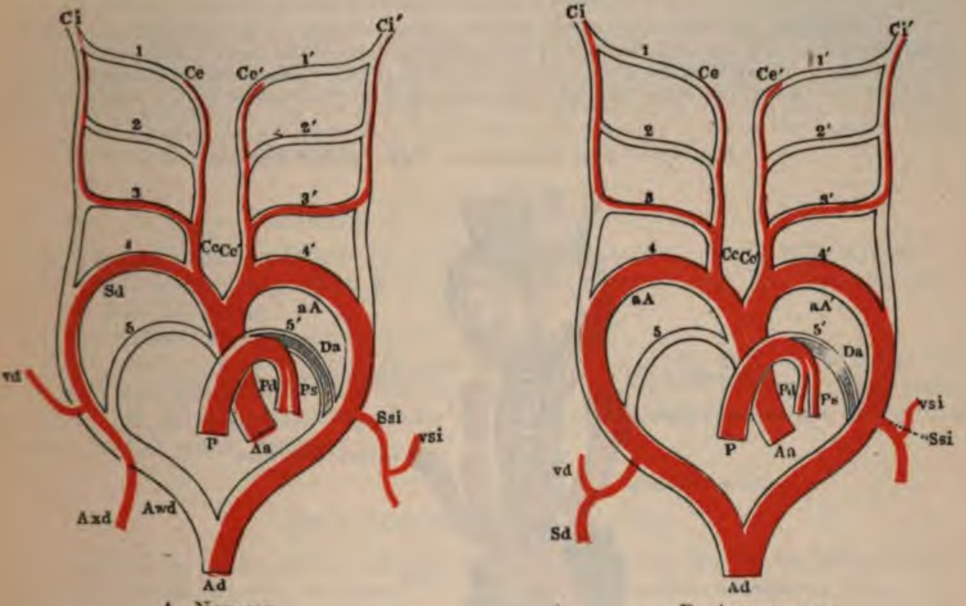
In the early embryonic stages a single stem arises from the arterial end of the heart and, dividing, passes forwards along the ventral wall of the pharynx. Opposite each branchial arch (p. 7) a lateral branch is given off from either stem and passes dorsally in the arch, finally uniting with its fellows of the same side to form a dorsal longitudinal stem, resting upon the dorsal wall of the pharynx. The two longitudinal stems so formed unite after a short course to form the descending aorta (figs. 403 A, 473).

When the septum of the heart forms, the bulbus arteriosus is divided by it into an anterior and a posterior vessel, the former, which is the pulmonary artery, being connected with the branches to the fifth pair of arches, while the posterior portion, which becomes the ascending portion of the aortic arch, is connected with the branches to the remaining arches (fig. 395).

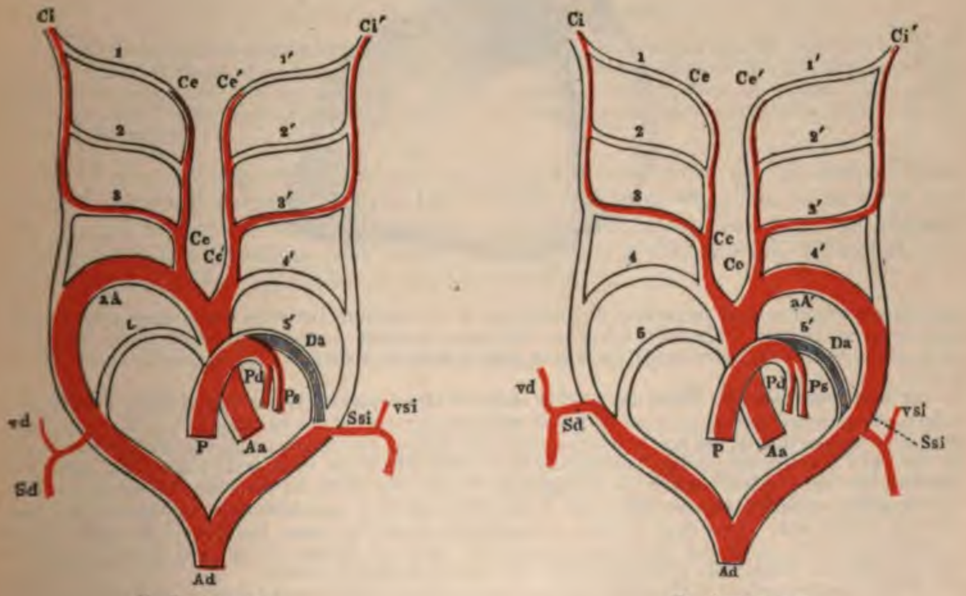
From the vessels passing to the fifth branchial arches the right and left pulmonary branches are developed, and the main fifth branch on the right side dissolves its connection with the right dorsal longitudinal stem, while that of the left side persists to form the ductus arteriosus (ligamentum arteriosum). The vessel of the left fourth arch persists to form the aortic arch, and that of the right arch forms the innominate artery and the proximal portion of the right subclavian; but the portion of the right dorsal longitudinal stem which intervenes between the

Fig. 403.—Scheme of the Normal and Abnormal Development of the Branches of the Aortic Arch. (After Henle.)

Aa. Aorta. aA. Aortic arch. Ad. Thoracic aorta. Cc. Common carotid. Ce. External carotid. Ci. Internal carotid. Da. Ductus arteriosus. P. Pulmonary artery. Pd and Ps. Right and left pulmonary arteries. Sd and Ssi. Right and left subclavian arteries. vd and vsi. Right and left vertebral arteries.


Ci
Ci'
1
1'
Ce
Ce'
2
2'
3
3'
4
4'
CcCc'
Sd
aA
aA'
5
5'
Da
Pd
Ps
P
Aa
vd
Ssi
vsi
Axd
Awd
Ad

A. Normal. B. Abnormal.


Ci
Ci'
1
1'
Ce
Ce'
2
2'
3
3'
4
4'
Cc
Cc'
aA
aA'
5
5'
Da
Pd
Ps
P
Aa
vd
Sd
Ssi
vsi
Ad

C. Abnormal. D. Abnormal.

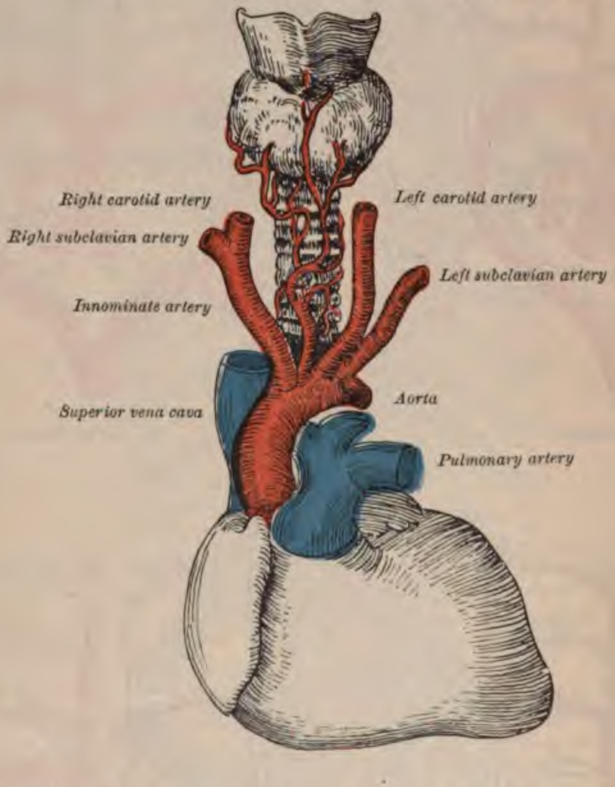
junction with the right fourth arch and that with the left aortic arch disappears, so that the innominate appears to arise from the aortic arch. The portions of the dorsal longitudinal stems of both sides intervening between the fourth and third arch vessels disappear, the more anterior portions of the stems become the internal carotids, the forward continuations of the ventral longitudinal stems become the external carotids, while the vessels of the third arches are represented by the connection between the two carotids of each side. The second and first arch vessels disappear at an early stage of development.

In the above description but five branchial arch vessels are recognised. Indications exist of a sixth vessel intervening between the fourth and fifth, but it disappears at an early stage of development and takes no part in the development of the adult condition.

Variations in the Arch of the Aorta

The variations met with in the arch of the aorta are usually to be explained as persistent fœtal conditions, and are often associated with abnormalities of the heart. Many of the variations are due to different modes of transformation of the primary vessels of the branchial arches, especially the fourth, and since the aorta and pulmonary artery develope from a common conus arteriosus, irregular and imperfect development of the septum between them may also produce numerous variations. The fact, too, that the heart develops originally high up in the neck and is gradually shifted downwards (p. 10) explains certain relations, for example, those of the nerves.

FIG. 404.—THE THYREOIDEA IMA. (After Henle.)



It has been seen (p. 508) that at one stage of development two aortic arches, a right and a left, are present, and such a condition is occasionally persistent in the adult. In such cases, owing to the portion of the aorta derived from the bulbus arteriosus being directed upwards and to the right and the descending aorta lying in the left side of the vertebral column, the right arch passes from right to left behind the œsophagus, which thus seems to perforate the aortic arch.

Another variation occasionally seen is the occurrence of an aortic arch curving to the right instead of the left. This may be due to a persistence of the lower portion of the right dorsal longitudinal stem and the disappearance of the left, as shown in fig. 403 C; or it may be associated with a complete inversion of all the viscera, a situs inversus.

If the lower portion of the right dorsal longitudinal trunk should persist, and the part of it which normally forms the proximal part of the right subclavian should, at the same time, disappear, the condition shown diagrammatically in fig. 403 D would occur. This represents the origin of the right subclavian from the descending portion of the aortic arch, and it is to be noted that in such cases the subclavian passes behind the œsophagus to reach the right side of the body.

Another group of variations is based on the persistence of the ductus arteriosus, which is derived from the fifth branchial arch vessel. In some rare cases of this kind accompanied by a partial or complete closure of the aorta, life has been maintained after birth and a collateral circulation for the aorta established. With this group belong the cases in which the pulmonary artery arises from the aorta; that is, where the blood of the pulmonary arteries passes from the aorta through the ductus arteriosus.

Variations in the number and the position of the vessels arising from the arch are extremely great, and many of these conditions are explained by comparative anatomy. There may be from one to six branches. The case of one branch is the normal in the horse. It involves the fusion of the two aortic stems and the shortening of the fourth arch so that the left subclavian joins with the common stem. The avian form with two innominate arteries is extremely rare. A more common form is the one found in most apes, in which the innominate and left carotid form one branch. The condition with these branches is usual; in rare instances the three branches are the two subclavians and a general carotid artery. When there are more than three branches the vertebral arteries are added or the extra branch may be the thyreoidea ima (fig. 404). The commonest form with four vessels is the one in which the left vertebral arises between the left carotid and subclavian. A rarer form is to be found when the order is right subclavian, right carotid, left carotid, and left subclavian. Where there are five arteries, the extra ones are the right subclavian and left vertebral. The case of six branches is due to the separate origin of both vertebrals and both subclavians.

Branches of the Arch of the Aorta

1. The **ascending portion** gives off—(1) Right coronary; (2) left coronary.

2. The **transverse portion** gives off—(1) Innominate; (2) left common carotid; (3) left subclavian.

3. The **descending portion** gives off no branch.

I. The branches of the first, or ascending, portion of the arch of the aorta are the **right** and **left coronary** for the supply of the tissues of the heart. They come off from the aorta, immediately above the aortic valves, from two of the dilatations known as the aortic sinuses.

THE CORONARY ARTERIES

A description of the course and branches of the coronary arteries has already been given in connection with the heart (p. 495) and need not be repeated here. The following diagram (fig. 405) will show at a glance the arrangement of the vessels.

Variations in the Coronary Arteries

(*a*) They may arise as a common trunk. (*b*) They may both arise from the same aortic sinus. (*c*) The anterior descending (interventricular) and terminal branches of the left coronary may arise separately from the aortic sinus. (*d*) One coronary artery may be larger than usual; the other vessel is then correspondingly small. (*e*) An extra coronary artery may arise from the pulmonary artery.

II. From the transverse part of the aortic arch are given off the **innominate,** the **left common carotid,** and the **left subclavian arteries.** The innominate and left carotid arise close together—indeed, so close that, when seen from the interior of the aorta, the orifices appear merely separated by a thin septum. The left subclavian arises a little less close to the left carotid.

THE INNOMINATE ARTERY

The **innominate** or **brachio-cephalic artery** (fig. 401), the largest branch of the arch of the aorta, extends from near the commencement of the transverse portion upwards and a little forwards and to the right, as high as the upper limit of the right sterno-clavicular joint where it bifurcates into the right common carotid and right subclavian arteries. It lies obliquely in front of the trachea, and measures from 3·7 to 5 cm. (1½ to 2 in.).

Relations.—**In front** of the artery are the manubrium, the origins of the sterno-hyoid and sterno-thyreoid muscles, the right sterno-clavicular joint, and the remains of the thymus gland. The left innominate vein crosses the root of the vessel, and the inferior thyreoid veins descend obliquely over it to end in the left innominate vein. The inferior cervical cardiac branches of the right vagus nerve pass in front of it on their way to the deep cardiac plexus.

Behind, it lies on the trachea, crossing that tube obliquely from left to right, and coming into contact above with the right pleura.

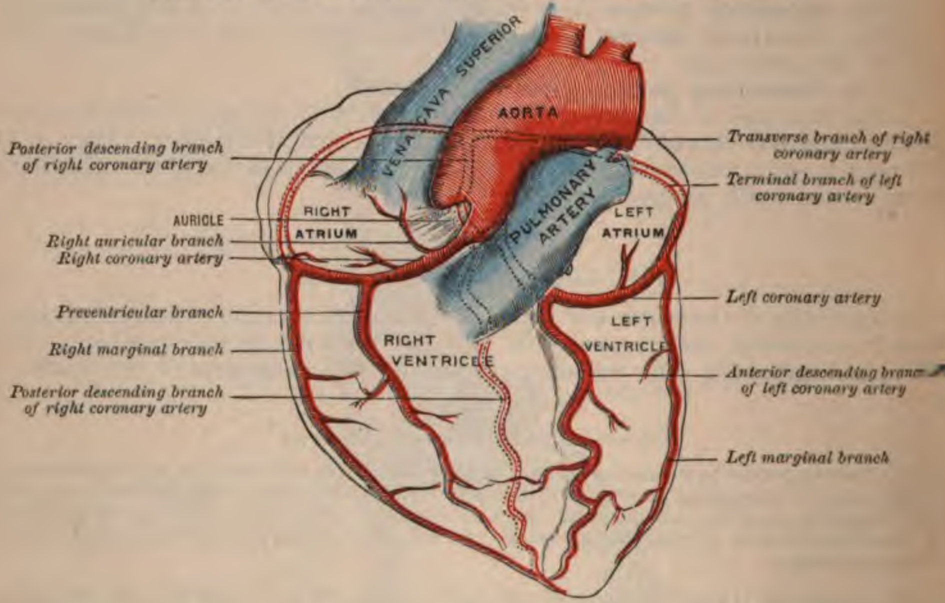
To the **right side** are the right innominate vein, the right vagus, and the pleura.

To the **left side** are the left common carotid, the remains of the thymus gland, the inferior thyreoid veins; and higher, the trachea.

Variations in the Innominate Artery

The **variations in the innominate artery** are of surgical interest. (*a*) It may divide lower than normal, thus decreasing the available space for the application of a ligature to it, but at the same time increasing the length of the first portion of the right subclavian artery. (*b*) It may divide higher than usual, and then may incline abnormally to the left, mounting in front of the trachea above the sternum. Under these circumstances it is in danger in the low operation of tracheotomy. (*c*) When abnormally long and inclining to the left, it may pass behind the trachea or the œsophagus to gain the right side. (*d*) It may give off the **thyreoidea ima** artery, and more rarely the vertebral, the internal mammary or a smaller twig, as a bronchial, thymic, pericardiac, or tracheal branch. The thyreoidea ima occurs in about 10 per cent. of bodies. It may arise also from the arch of the aorta (fig. 404) or from the right common carotid.

Fig. 405.—Scheme of the Coronary Arteries. (Walsham.)


VENA CAVA SUPERIOR
AORTA
PULMONARY ARTERY
RIGHT ATRIUM
LEFT ATRIUM
RIGHT VENTRICLE
LEFT VENTRICLE
Posterior descending branch of right coronary artery
AURICLE
Right auricular branch
Right coronary artery
Preventricular branch
Right marginal branch
Posterior descending branch of right coronary artery
Transverse branch of right coronary artery
Terminal branch of left coronary artery
Left coronary artery
Anterior descending branch of left coronary artery
Left marginal branch

The **branches of the innominate artery** are:—(1) The right common carotid; and (2) the right subclavian. These are terminal branches. There are usually no collateral branches from this vessel, but at times the **thyreoidea ima** may arise from it.

THE COMMON CAROTID ARTERIES

The **common carotid arteries** pass up deeply from the thorax on either s of the neck to about the level of the upper border of the thyreoid cartilage, wh they divide into the external and internal carotid arteries. The **external car** supplies the structures at the upper part of the front and side of the neck, the lary pharynx, tongue, face, the upper part of the back of the neck, the structures in pterygoid region, the scalp, and in chief part the membranes of the brain. T **internal carotid** gives off no branch in the neck, but enters the cranium and supp the greater part of the brain, the structures contained in the orbit, and portions the membranes of the brain.

The common carotid artery on the right side arises from the bifurcation of innominate behind the sterno-clavicular joint; on the left side from the arch of aorta a little to the left of the innominate artery, and on a somewhat posterior plane to that vessel (fig. 401). The portion of the left common carotid artery which extends from the arch of the aorta to the level of the sterno-clavicular articulation lies deeply in the chest, and requires a separate description; but above the level of the sterno-clavicular joint the relations of the right and left carotids are practically the same, and are given under the account of the right common carotid.

THORACIC PORTION OF THE LEFT COMMON CAROTID ARTERY

Within the thorax the left common carotid is deeply placed behind the manubrium of the sternum, and is overlapped by the left lung and pleura. It arises from the middle of the transverse portion of the aortic arch, close to the left side of the innominate artery, and a little posterior to that vessel, and ascends obliquely in front of the trachea to the left sterno-clavicular articulation, above which its relations are similar to those of the right common carotid.

Relations.—In front, but at some little distance, are the manubrium and the origins of the left sterno-hyoid and sterno-thyreoid muscles; whilst in contact with it are the remains of the thymus gland, and the loose connective tissue and fat of the superior mediastinum. Crossing its root is the left innominate vein.

Behind, it lies successively upon the trachea, the œsophagus (which here inclines a little to the left), the thoracic duct, and the left recurrent (laryngeal) nerve.

To its **right side** is the root of the innominate artery, and higher up are the trachea and the inferior thyreoid veins.

To its **left side,** but on a posterior plane, are the left subclavian artery and the left vagus nerve; and, slightly overlapping it, the edge of the left pleura and lung.

The **variations in the origin of the left common carotid** are given under VARIATIONS OF THE ARCH OF THE AORTA (page 511).

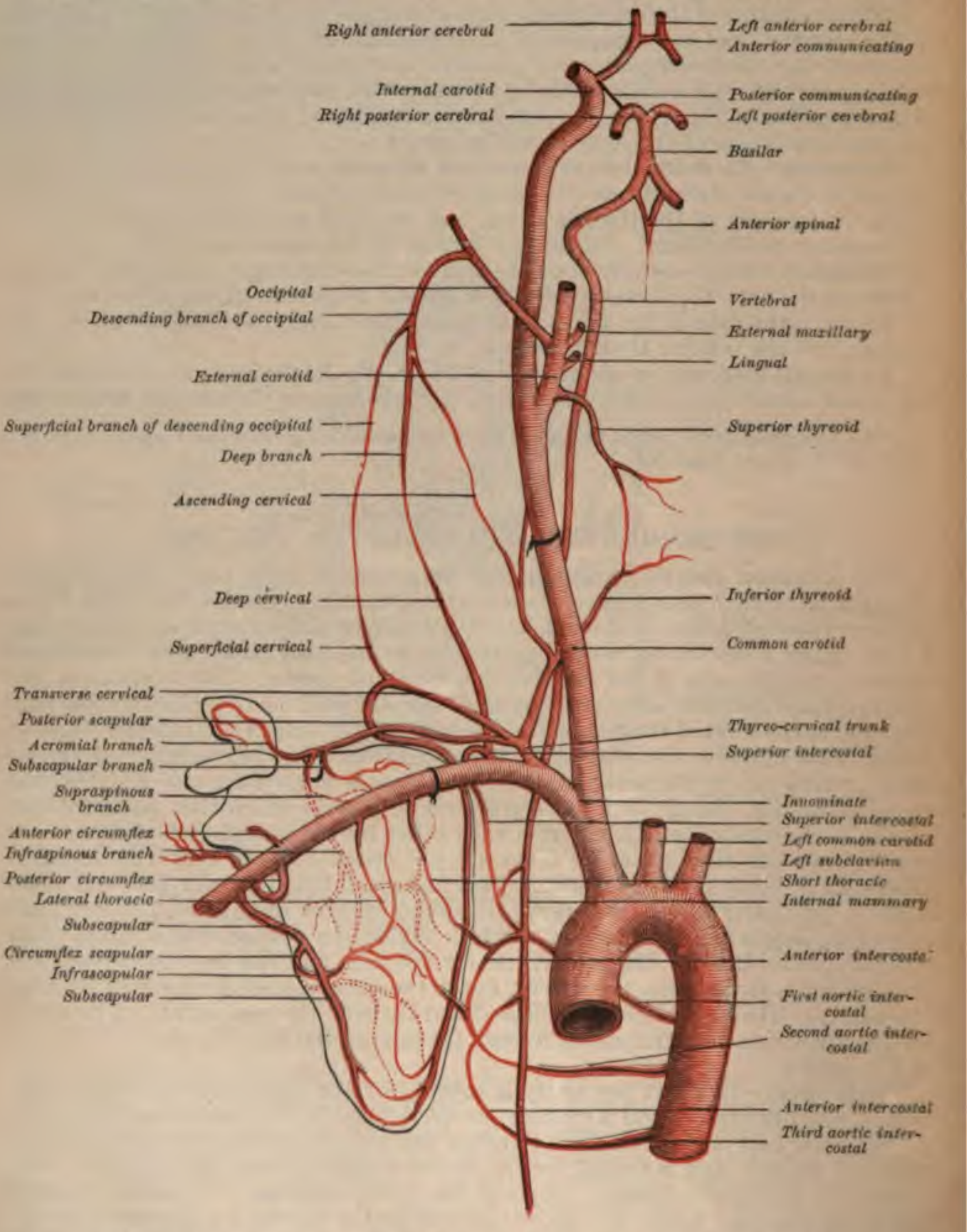
THE COMMON CAROTID ARTERY IN THE NECK

The **common carotid artery in the neck** extends from the sterno-clavicular articulation to the upper border of the thyreoid cartilage on a level with the fourth cervical vertebra, where it divides into the external and internal carotid arteries. A line drawn from the sterno-clavicular joint to the interval between the mastoid process and the angle of the jaw would indicate its course. The artery is at first deeply placed beneath the sterno-mastoid, sterno-hyoid, and sterno-thyreoid muscles, and at the level of the top of the sternum is only 2 cm. (¾ in.) distant from its fellow of the opposite side, and merely separated from it by the trachea. As the carotid arteries run up the neck, however, they diverge in the form of a V and become more superficial, though on a plane posterior to that in which they lie at the root of the neck, and are separated from each other by the larynx and pharynx. At their bifurcation they are about 6 cm. (2¼ in.) apart. The common carotid is contained in a sheath of fascia common to it and the internal jugular vein and vagus nerve. The artery, vein, and nerve, however, are not in contact, but separated from one another by fibrous septa, which divide the common sheath into three compartments: one for the artery, one for the vein, and one for the nerve. The vein, which is larger than the artery, lies to the outer side, and somewhat overlaps the artery. The vagus nerve lies behind and between the two vessels. The artery on the right side measures about 9·5 cm. (3¾ in.); on the left side, about 12 cm. (4¾ in.) in length.

Relations.—In front the artery is covered by the skin, superficial fascia, platysma, and deep fascia, and is more or less overlapped by the sterno-mastoid muscle. At the lower part of the neck it is covered in addition by the sterno-hyoid and sterno-thyreoid muscles, and is crossed by the anterior jugular vein, and is often overlapped by the thyreoid body. Opposite the cricoid cartilage it is crossed obliquely by the omo-hyoid muscle; and above this spot by the middle and superior thyreoid, the lingual, and generally the anterior facial veins in their course to the internal jugular, and by the sterno-mastoid artery as it passes from the superior thyreoid artery, its usual source, on its way down to the sterno-mastoid muscle. Along the anterior border of the sterno-mastoid there is a communicating vein between the facial and anterior jugular veins, which, as it crosses the line of the carotid artery, is in danger of being wounded in the operation of tying the carotid. The descendens hypoglossi nerve generally descends in front of the carotid sheath, being there joined by the communicantes hypoglossi, one or two small branches of the second and third cervical nerves. At times this nerve runs within the sheath. There are usually two lymphatic glands about the bifurcation of the artery. These are often found enlarged and infiltrated in cancer of the lip and tongue.

FIG. 406.—THE COLLATERAL CIRCULATION AFTER LIGATURE OF THE COMMON CAROTID AND SUBCLAVIAN ARTERIES.

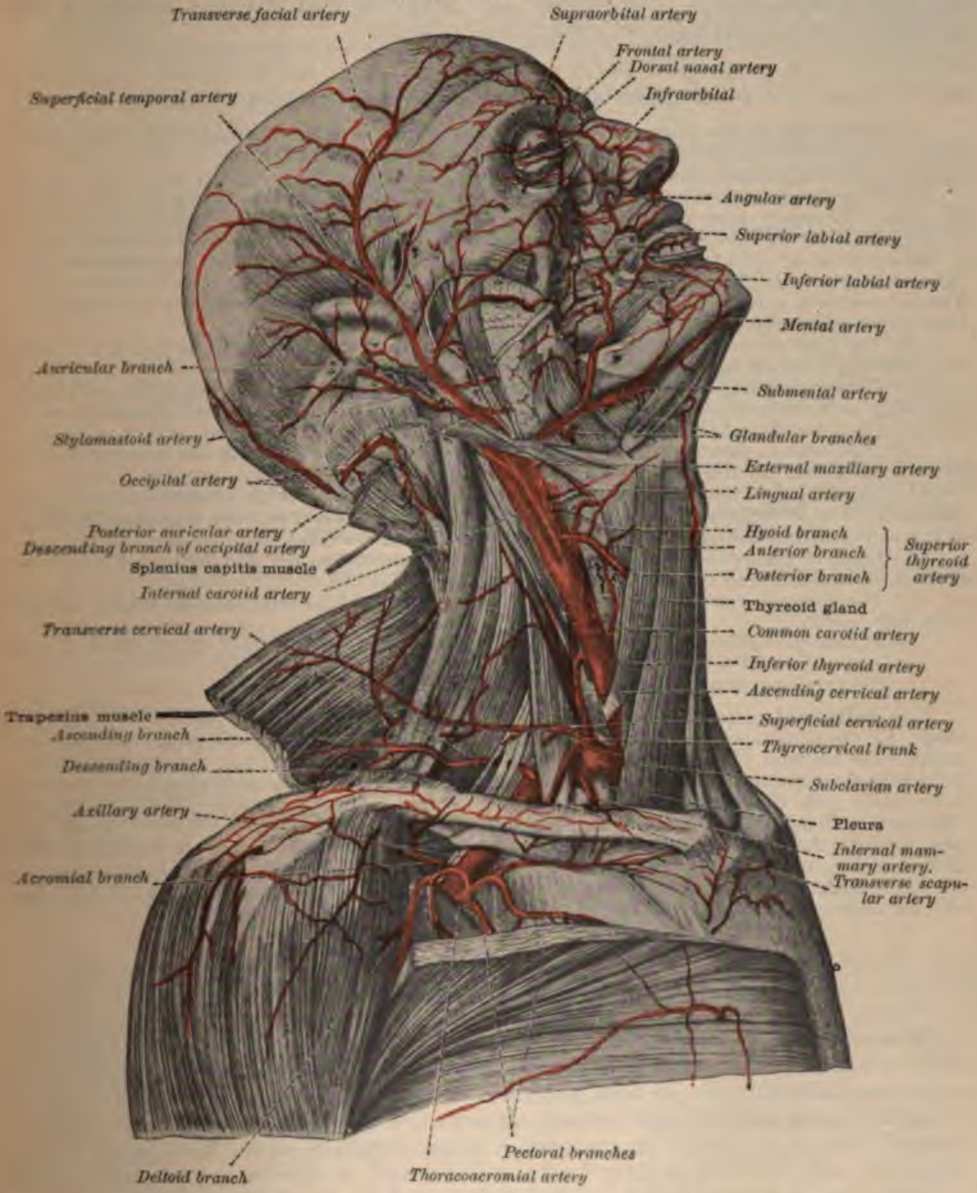
(A ligature is placed on the common carotid and on the third portion of the subclavian artery.)


Right anterior cerebral
Left anterior cerebral
Anterior communicating
Internal carotid
Posterior communicating
Right posterior cerebral
Left posterior cerebral
Basilar
Anterior spinal
Occipital
Vertebral
Descending branch of occipital
External maxillary
Lingual
External carotid
Superficial branch of descending occipital
Superior thyreoid
Deep branch
Ascending cervical
Deep cervical
Inferior thyreoid
Superficial cervical
Common carotid
Transverse cervical
Posterior scapular
Thyreo-cervical trunk
Acromial branch
Superior intercostal
Subscapular branch
Supraspinous branch
Innominate
Superior intercostal
Anterior circumflex
Left common carotid
Infraspinous branch
Left subclavian
Posterior circumflex
Short thoracic
Lateral thoracic
Internal mammary
Subscapular
Circumflex scapular
Anterior intercostal
Infrascapular
Subscapular
First aortic intercostal
Second aortic intercostal
Anterior intercostal
Third aortic intercostal

Behind, the common carotid lies on the longus colli and scalenus anterior below, and longus capitis (rectus capitis anterior major) above. Posterior to the artery, but in the same sheath, is the vagus nerve; and posterior to the sheath, the chain of the sympathetic and the cervical cardiac branches of the sympathetic and vagus nerves. At the lower part of the neck the inferior thyreoid artery courses obliquely behind the carotid, as does likewise the recurrent (laryngeal) nerve.

Internally, from below upwards, are the trachea and œsophagus, with the recurrent (laryngeal) nerve in the groove between them, and the terminal branches of the inferior thyreoid artery, the lateral lobe of the thyreoid body, the cricoid cartilage, the thyreoid cartilage, and the lower part of the pharynx. At the angle of bifurcation is a vascular structure known as the **ganglion intercaroticum** or the **carotid gland.**

FIG. 407.—ARTERIES OF THE HEAD AND NECK. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Transverse facial artery
Supraorbital artery
Frontal artery
Dorsal nasal artery
Superficial temporal artery
Infraorbital
Angular artery
Superior labial artery
Inferior labial artery
Mental artery
Auricular branch
Submental artery
Stylomastoid artery
Glandular branches
External maxillary artery
Occipital artery
Lingual artery
Posterior auricular artery
Descending branch of occipital artery
Splenius capitis muscle
Internal carotid artery
Hyoid branch
Anterior branch
Posterior branch
Superior thyreoid artery
Thyreoid gland
Transverse cervical artery
Common carotid artery
Inferior thyreoid artery
Ascending cervical artery
Trapezius muscle
Ascending branch
Superficial cervical artery
Descending branch
Thyreocervical trunk
Subclavian artery
Axillary artery
Pleura
Internal mammary artery.
Acromial branch
Transverse scapular artery
Pectoral branches
Deltoid branch
Thoracoacromial artery

Externally are the internal jugular vein and the vagus nerve. On the right side, at the root of the neck, the vein diverges somewhat from the artery, leaving a space in which the vagus nerve and vertebral artery are exposed. On the left side the vein approaches and somewhat overlaps the artery, thus leaving no interval corresponding to that on the right side.

The cricoid cartilage is, as a rule, taken as the centre of the incision in the operation for ligature of the common carotid artery. The incision is made in the line of the vessel parallel to the anterior margin of the sterno-mastoid muscle. The omo-hyoid forms one of the chief rallying points in the course of the operation for ligature of the artery above that muscle, the usual situation. The artery is found beating at the angle formed by the omo-hyoid with the sterno-mastoid.

Branches.—(1) *External* and (2) *internal carotid arteries.* The common carotid gives off no lateral branch, and consequently does not diminish in size as it runs up the neck. It is often a little swollen just below its bifurcation, a condition that should not be mistaken for an aneurismal dilation.

Variations of the Common Carotid Arteries

The **variations in the origin of the common carotid** have been already mentioned under VARIATIONS OF THE CHIEF BRANCHES OF THE AORTIC ARCH (page 511).

The following variations are of surgical interest:—

(A) The artery may cross obliquely the lower part of the trachea above the level of the sternum. This may occur on the **right side**: (*a*) when the innominate is situated abnormally to the left of the middle line; (*b*) when the right common carotid arises as the second branch of the aortic arch; and (*c*) when the right and left common carotids arise as a common stem from the aorta. On the **left side**: when the left common carotid arises from the innominate. The left common carotid varies more than the right, coming either from the innominate or from a common stem with the left.

(B) The right common carotid may, when arising from the aorta, run behind the trachea and œsophagus to the right side of the neck.

(C) The commencement of the right common carotid may be above or below the usual spot, according as the innominate bifurcates higher or lower than usual. A low bifurcation of the innominate is somewhat the more common abnormality.

(D) The common carotid may run in a very tortuous manner, forming one or more distinct loops in its course up the neck.

(E) The artery may bifurcate higher or lower than normal. A high bifurcation is the more common. The bifurcation may occur as high as the hyoid bone, or even styloid process; or as low as the cricoid cartilage, or within 3·7 cm. (1½ in.) of its origin.

(F) The artery may not bifurcate, but give off the branches usually derived from the external division as it ascends in the neck.

(G) The common carotid may be absent, the external and internal carotids arising directly from the aorta.

(H) It may give off one or more of the branches usually derived from the external carotid.

(I) It may give off a thyreoidea ima.

(J) The vagus nerve may run in front of the artery instead of behind it.

The **collateral circulation** (fig. 406), after ligature of the common carotid, is carried on chiefly by the anastomosis of the internal carotid with the internal carotid of the opposite side through the circle of Willis; by the vertebral with the opposite vertebral; by the inferior thyreoid with the superior thyreoid; by the deep cervical branch of the costo-cervical trunk (superior intercostal) with the descending branch of the occipital; by the superior thyreoid, lingual, external maxillary (facial), occipital, and temporal, with the corresponding arteries of the opposite side, and by the ophthalmic with the angular. The anastomosis between the deep cervic branch of the costo-cervical trunk with the descending branch of the occipital is an importa one; it is situated deeply at the back of the neck, and is to be found lying between the ser spinalis capitis (complexus) and cervicis muscles.

THE EXTERNAL CAROTID ARTERY

The **external carotid artery,** the smaller of the two branches into which t common carotid divides at the upper border of the thyreoid cartilage, is distribut to the anterior part of the neck, the face, and the side of the skull, including t skin, the bones, and the dura mater. It is at first situated internal to the intern carotid; but as it ascends in the neck it forms a gentle curve, with its convexi forwards, and, running slightly backwards as well as upwards, terminates opp site the neck of the lower jaw just below the condyle, by dividing into the intern maxillary and superficial temporal arteries. It here lies superficial to the intern carotid, from which it is separated by a portion of the parotid gland. At its orig it is overlapped by the anterior margin of the sterno-mastoid, and is covered by t superficial fascia, platysma, and deep fascia. Higher up the neck it is deeply place passing beneath the stylo-hyoid muscle, the posterior belly of the digastric musc and the hypoglossal nerve; and finally becomes embedded in the parotid glan where it divides into its terminal branches. It is separated from the internal carotid artery posteriorly by the stylo-pharyngeus and stylo-glossus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus nerve, a portion of the parotid gland, and the stylo-hyoid ligament; or, if the styloid process is abnormally long, by that process itself. It measures about 6·5 cm. (2½ in.).

Relations.—In front, in addition to the skin, superficial fascia, platysma, and deep fascia, it has the hypoglossal nerve, the lingual and common facial (temporo-maxillary) veins, the posterior belly of the digastric and stylo-hyoid muscles, the posterior facial vein, the superior cervical lymphatic glands, branches of the facial nerve, and the parotid gland. The sterno-mastoid also overlaps it in the natural state of the parts.

Behind, it is in relation with the internal carotid, from which it is separated by the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus nerve, the stylo-hyoid ligament, and the parotid gland. The superior laryngeal nerve crosses behind both the external and internal carotid arteries.

Internally, it is in relation with the hyoid bone, the pharyngeal wall, the ramus of the jaw, the stylo-mandibular ligament which separates it from the submaxillary gland, and the parotid gland.

Externally, in the first part of its course, it is in contact with the internal carotid artery.

Chief Variations of the External Carotid Artery

The **variations of the external carotid artery** are not of much surgical importance. The variations in its origin have been discussed under VARIATIONS OF THE COMMON CAROTID.

(A) It may be absent, the branches usually derived from it coming off from the upward continuation of the common trunk.

(B) It may run superficial to the stylo-hyoid muscle.

(C) Its branches may come off irregularly, or may be diminished or increased in number either by two or more arising as a common stem; or by its giving origin to branches not usually derived from it, as the sterno-mastoid branch of either the superior thyreoid or occipital artery.

(D) At times all its branches come off close together just above its origin.

The **branches of the external carotid** are usually given off in the following order, from below upwards:—

1. Ascending pharyngeal.
2. Superior thyreoid.
3. Lingual.
4. External maxillary (facial).
5. Sternocleidomastoid.
6. Occipital.
7. Posterior auricular.
8. Superficial temporal.
9. Internal maxillary.

1. THE ASCENDING PHARYNGEAL ARTERY

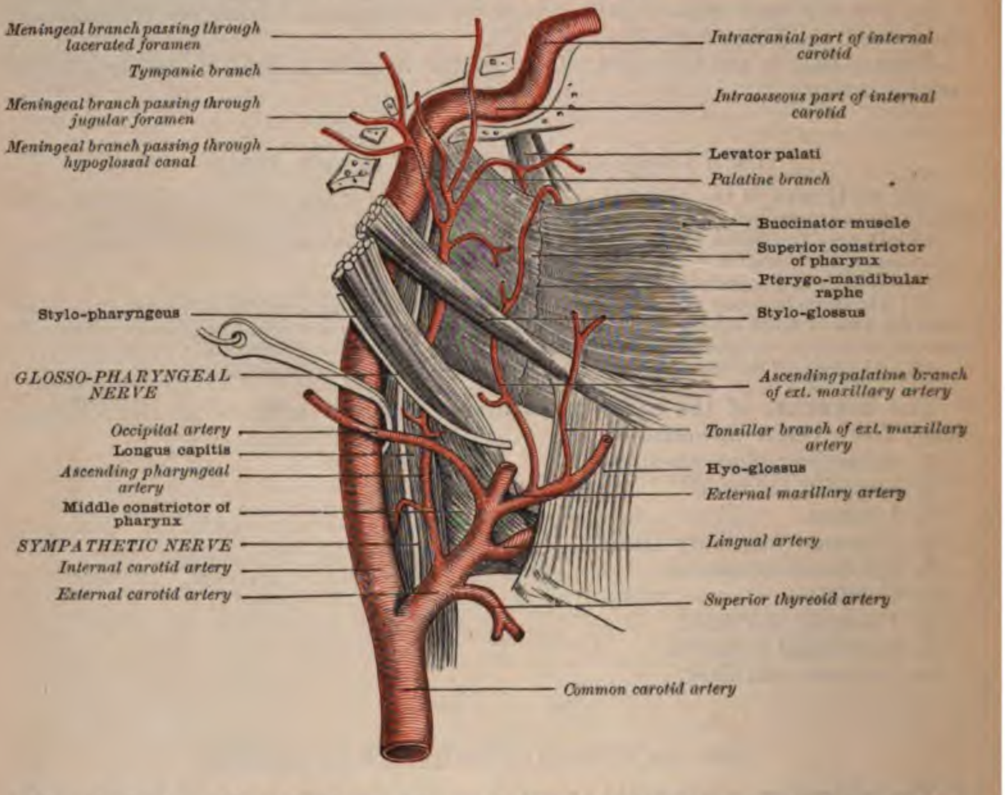
The **ascending pharyngeal artery** is usually the first or second branch of the external carotid. Occasionally it comes off at the bifurcation of the common carotid from the common carotid itself. It is a long slender vessel which runs deeply seated up the neck to the base of the skull, having the walls of the pharynx and the tonsil **internally,** the internal carotid artery **externally,** and the vertebral column, the longus capitis (rectus capitis anterior major), and the sympathetic nerve **posteriorly. In front** it is crossed by the stylo-glossus (see fig. 408) and stylo-pharyngeus muscles and the glosso-pharyngeal nerve.

BRANCHES OF THE ASCENDING PHARYNGEAL ARTERY

The branches of the ascending pharyngeal artery are small and variable. They supply the longus and rectus capitis muscles, the upper cervical sympathetic ganglion and adjacent lymph-nodes, as well as the pharynx, soft palate, ear, cranial nerves, and meninges.

The **pharyngeal** branches supply the superior and middle constrictor muscles and the mucous membrane lining them. These vessels anastomose with branches of the superior thyreoid. One branch (the **palatine**) passes over the upper edge of the superior constrictor to the soft palate and its muscles. This branch follows a course similar to that taken by the ascending palatine artery, and when the latter is small may take its place. It generally gives off small twigs to the Eustachian tube and tonsil. The **tympanic** branches accompany the tympanic branch of the glosso-pharyngeal nerve through the tympanic canaliculus into the tympanum, and anastomose with the other tympanic arteries. The **posterior meningeal** branches are distributed to the membranes of the brain. Some of these pass with the jugular vein through the jugular foramen into the cranium, and supply the dura mater in the posterior fossa of the skull. Others occasionally reach the same fossa through the hypoglossal (anterior condyloid) canal in company with the hypoglossal nerve; while others pass through the cartilage of the lacerated foramen and supply the middle fossa of the skull.

FIG. 408.—SCHEME OF RIGHT ASCENDING PHARYNGEAL ARTERY. (Walsham.)
The internal carotid artery is hooked aside.


Meningeal branch passing through lacerated foramen
Tympanic branch
Meningeal branch passing through jugular foramen
Meningeal branch passing through hypoglossal canal
Stylo-pharyngeus
GLOSSO-PHARYNGEAL NERVE
Occipital artery
Longus capitis
Ascending pharyngeal artery
Middle constrictor of pharynx
SYMPATHETIC NERVE
Internal carotid artery
External carotid artery
Intracranial part of internal carotid
Intraosseous part of internal carotid
Levator palati
Palatine branch
Buccinator muscle
Superior constrictor of pharynx
Pterygo-mandibular raphe
Stylo-glossus
Ascending palatine branch of ext. maxillary artery
Tonsillar branch of ext. maxillary artery
Hyo-glossus
External maxillary artery
Lingual artery
Superior thyreoid artery
Common carotid artery

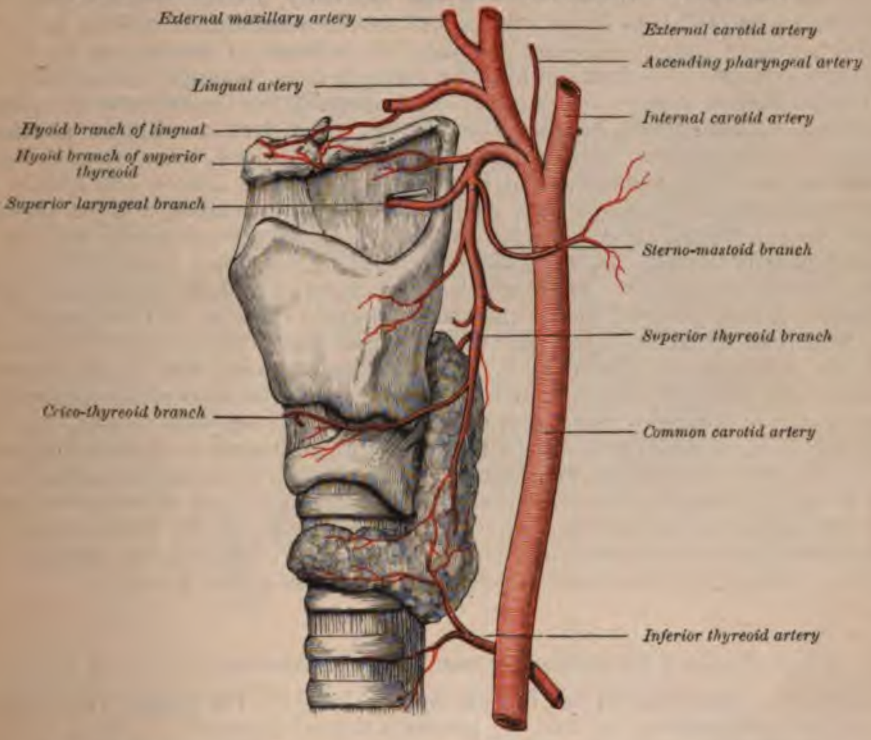
2. THE SUPERIOR THYREOID ARTERY

The **superior thyreoid artery** arises from the front of the external carotid a little above the origin of that vessel, and, coursing forwards, inwards, and then downwards, in a tortuous manner, supplies the depressor muscles of the hyoid bone, the larynx, the thyreoid body, and the lower part of the pharynx. The artery at first runs forwards and a little upwards, just beneath the greater cornu of the hyoid bone. In this part of its course it lies in the superior carotid triangle, and is quite superficial, being covered only with the integument, fascia, and platysma. It next turns downwards, and passes beneath the omo-hyoid, sterno-hyoid, and sterno-thyreoid muscles, and ends at the upper part of the thyreoid body by breaking up into branches, some of which pass downwards in front, and others behind the lateral lobe of the thyreoid to anastomose with ascending branches from the inferior thyreoid; whilst others, again, but much smaller in size, pass in the substance of the isthmus across the front of the trachea to anastomose with the superior thyreoid artery of the opposite side. These vessels, however, are so small that if the isthmus is divided accurately in the middle line, there is practically no arterial hæmorrhage. From the branch to the thyreoid body twigs are given off to the inferior constrictor and the upper part of the œsophagus. These anastomose with branches from the inferior thyreoid. The superior thyreoid vein passes beneath the artery on its way to the internal jugular vein. The superior thyreoid is the artery most commonly divided in cases of suicidal wounds of the throat.

BRANCHES OF THE SUPERIOR THYREOID ARTERY

The named **branches of the superior thyreoid artery** are:—(1) The hyoid; (2) the sterno-mastoid; (3) the superior laryngeal; and (4) the crico-thyreoid.

FIG. 409.—SCHEME OF LEFT SUPERIOR THYREOID ARTERY. (Walsham.)


External maxillary artery
External carotid artery
Ascending pharyngeal artery
Lingual artery
Internal carotid artery
Hyoid branch of lingual
Hyoid branch of superior thyreoid
Superior laryngeal branch
Sterno-mastoid branch
Superior thyreoid branch
Crico-thyreoid branch
Common carotid artery
Inferior thyreoid artery

(1) The **hyoid** is usually a small twig which passes along the lower border of the hyoid bone, lying on the thyreo-hyoid membrane under cover of the thyreo-hyoid and sterno-hyoid muscles. It supplies the infra-hyoid bursa and the thyreo-hyoid muscle, and anastomoses with its fellow of the opposite side, and with the hyoid branch of the lingual. When the latter artery is small, the hyoid branch of the superior thyreoid is usually comparatively large, and *vice versâ*.

(2) The **sterno-mastoid** (fig. 409) courses downwards and backwards across the carotid sheath, and entering the sterno-mastoid supplies the middle portion of that muscle. It gives off slender twigs to the thyreo-hyoid, sterno-hyoid, and omo-hyoid muscles, and the platysma and integuments covering it. At times the vessel arises directly from the external carotid. It lies usually somewhere in the upper part of the incision for tying the common carotid above the omo-hyoid muscle.

(3) The **superior laryngeal** (fig. 409) passes inwards and forwards beneath the thyreo-hyoid muscle, and, perforating the thyreo-hyoid membrane along with the superior laryngeal nerve, supplies the intrinsic muscles and mucous lining of the

larynx. Its further distribution within the larynx is given with the description of that organ. This branch sometimes arises from the external carotid direct. It may enter the larynx by passing through a foramen in the thyreoid cartilage.

(4) The **crico-thyreoid**—usually insignificant in size—passes across the crico-thyreoid membrane immediately beneath the lower border of the thyreoid cartilage. It anastomoses with its fellow of the opposite side, and usually sends a small branch through the membrane into the interior of the larynx. Occasionally a considerable twig descends over the cricoid cartilage to enter the isthmus of the thyreoid gland. The crico-thyreoid has, however, frequently been seen of comparatively large size—once as large as the radial, and crossing the membrane obliquely. In order to avoid injuring the crico-thyreoid artery in the operation of laryngotomy, it is usual, if the operation has to be done in a hurry, to make the incision through the crico-thyreoid membrane in a transverse direction, and as near to the cricoid cartilage as possible.

3. THE LINGUAL ARTERY

The **lingual artery** (fig. 410) arises from the front of the external carotid, between the superior thyreoid and external maxillary (facial) arteries, often as a common trunk with the latter vessel, and nearly opposite or a little below the greater cornu of the hyoid bone. It may, for purposes of description, be divided into three portions: the **first, or oblique,** extends from its origin to the outer edge of the hyo-glossus muscle; the **second,** or **horizontal,** lies beneath the hyo-glossus; the **third,** or **ascending,** beneath the tongue. The **first** or **oblique portion** is situated in the superior carotid triangle, and is superficial, being covered merely by the integuments, platysma, and deep fascia. Here it lies on the middle constrictor muscle and superior laryngeal nerve. After ascending a short distance, it curves downwards and forwards beneath the hypoglossal nerve, and, in the **second part of its course,** runs horizontally along the upper border of the hyoid bone, beneath the hyo-glossus, by which it is separated from the hypoglossal nerve, the posterior belly of the digastric and the stylo-hyoid muscles, and the lingual vein. In this part of its course it lies successively on the middle constrictor of the pharynx and the genio-glossus muscle, and crosses a small triangular space known as 'Lesser's triangle,' the sides of which are formed by the tendons of the digastric, the base by the hypoglossal nerve, and the floor by the hyo-glossus muscle, in which situation it is usually tied. In the **third part of its course** it ascends tortuously, usually beneath the anterior margin of the hyo-glossus, to the under surface of the tongue, and is thence continued to the tip of that structure lying between the lingualis and the genio-glossus muscles. From the anterior edge of the hyo-glossus to its termination it is only covered by the mucous membrane of the under surface of the tongue. This part of the vessel is sometimes called the ranine artery.

BRANCHES OF THE LINGUAL ARTERY

The named **branches of the lingual artery** are:—(1) The hyoid; (2) the dorsal lingual; (3) the sublingual; and (4) the deep lingual (ranine).

(1) The **hyoid** branch (fig. 410) is a small vessel which arises from the first part of the lingual, and courses along the upper border of the hyoid bone, superficial to the hyo-glossus, but beneath the insertion of the posterior belly of the digastric and the stylo-hyoid. It anastomoses with its fellow of the opposite side, and with the hyoid branch of the superior thyreoid artery, and supplies the contiguous muscles.

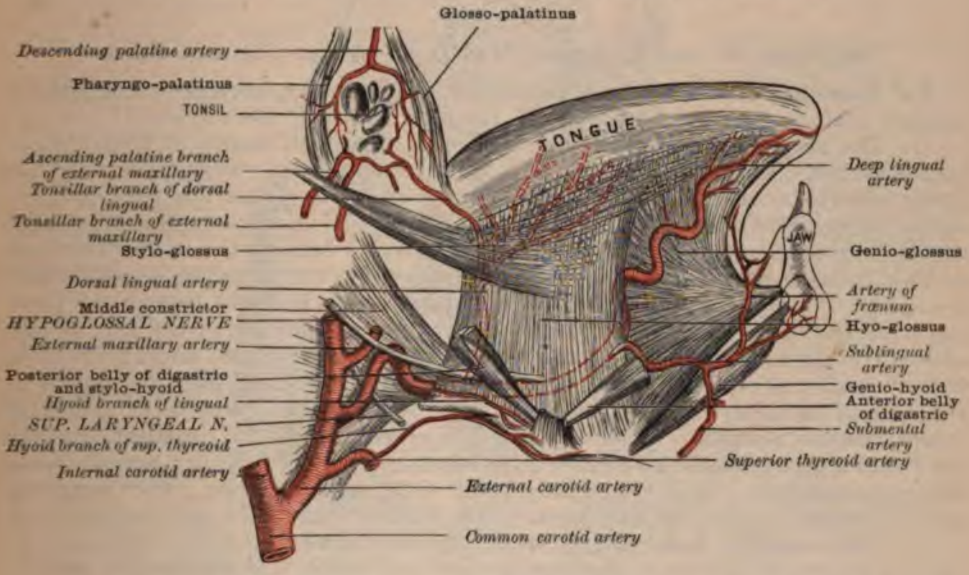
(2) The **dorsal lingual** (fig. 410) arises from the second portion of the lingual artery, usually under cover of the posterior edge of the hyo-glossus muscle. It ascends to the back of the dorsum of the tongue, and, dividing into branches, supplies the mucous membrane on each side of the V formed by the vallate papillæ. It also supplies the pillars of the fauces and the tonsil, where it anastomoses with the other faucial and tonsillar arteries. Instead of a single artery, as above described, there may be several small vessels running directly to the parts mentioned. The artery anastomoses in the mucous membrane by very small branches with the vessel of the opposite side; but the anastomosis is so minute that when one lingual artery is injected the injection merely passes across to the opposite side at the tip of

the tongue; and when the tongue is divided accurately in the middle line, as in the removal of one-half of that organ, practically no hæmorrhage occurs.

(3) The **sublingual artery** (fig. 410) usually comes off from the lingual at the anterior margin of the hyo-glossus. It passes beneath the mylo-hyoid to the sublingual gland, which it supplies, and, perforating the muscle, anastomoses with the submental artery, a branch of the external maxillary (facial). It also supplies branches to the side of the tongue, and gives off a terminal twig, which anastomoses beneath the mucous membrane of the floor of the mouth (to which it also gives twigs) with the artery of the opposite side. The **artery of the frænum** is usually derived from this vessel (fig. 410).

(4) The **deep lingual** or **ranine artery,** the termination of the lingual, courses forwards beneath the mucous membrane, on the under surface of the tongue, to the tip. It lies external to the genio-glossus, between that muscle and the inferior lingualis, and is accompanied by the lingual vein and terminal branch of the lingual nerve. It follows a very tortuous course, so that it is not stretched when the tongue is protruded. Branches are given off from it to the contiguous muscles and mucous membrane. Near the tip of the tongue it communicates with its fellow of the opposite side, as shown by the fact that when the lingual artery of one side is injected, the injection fluid passes into the branches of the artery of the other side.

Fig. 410.—Scheme of the Right Lingual Artery. (Walsham.)


Glosso-palatinus
Descending palatine artery
Pharyngo-palatinus
TONSIL
TONGUE
Ascending palatine branch of external maxillary
Tonsillar branch of dorsal lingual
Tonsillar branch of external maxillary
Stylo-glossus
Dorsal lingual artery
Middle constrictor
HYPOGLOSSAL NERVE
External maxillary artery
Posterior belly of digastric and stylo-hyoid
Hyoid branch of lingual
SUP. LARYNGEAL N.
Hyoid branch of sup. thyreoid
Internal carotid artery
External carotid artery
Common carotid artery
Deep lingual artery
JAW
Genio-glossus
Artery of frænum
Hyo-glossus
Sublingual artery
Genio-hyoid
Anterior belly of digastric
Submental artery
Superior thyreoid artery

4. THE EXTERNAL MAXILLARY (FACIAL) ARTERY

The **external maxillary** or **facial artery** (fig. 411) arises immediately above the lingual from the fore part of the external carotid, at times as a common trunk with the lingual. It courses forwards and upwards in a tortuous manner to the lower jaw, and, passing over the body of this bone at the anterior edge of the masseter muscle, winds obliquely upwards and forwards over the face to the inner canthus of the eye, where it anastomoses, under the name of the **angular artery,** with the nasal branch of the ophthalmic. It is usually divided into two portions—the cervical and the facial.

The **cervical portion** (fig. 411) ascends tortuously from its origin from the external carotid upwards and forwards beneath the posterior belly of the digastric and stylo-hyoid muscles, and usually also beneath the hypoglossal nerve, and then, making a turn, runs horizontally forwards for a short way beneath the jaw, either imbedded in or lying under the submaxillary gland. It has here the mylo-hyoid and stylo-glossus beneath it. On leaving the cover of the gland it forms a loop passing first downwards and then upwards over the lower border of the jaw immediately in front of the masseter muscle, where it is superficial, being merely covered by the integument and platysma. Here it can be felt beating, and can be readily compressed. In the above course it lies in the posterior part of the submaxillary triangle, and, in addition to the structures already mentioned as crossing it, is covered by the skin, superficial fascia, and platysma, and by one or two submaxillary lymphatic nodes. The vein is separated from the artery by the submaxillary gland, the posterior belly of the digastric muscle, the stylo-hyoid muscle, and the hypoglossal nerve.

The **facial portion** (fig. 411) of the external maxillary artery ascends tortuously forwards towards the angle of the mouth, passing under the platysma (risorius) and zygomatic muscles and the zygomatic and buccal branches of the facial nerve. It here lies upon the jaw and the buccinator muscle. Thence it courses upwards by the side of the nose towards the inner canthus of the eye, being covered by the quadratus (levator) labii superioris and infraorbital branches of the facial nerve, and lying on the caninus (levator anguli oris) (sometimes on the quadratus (levator) labii superioris, instead of below it) and the infraorbital branches of the fifth nerve. The facial vein takes a much straighter course than the artery, is separated from it by the zygomatic muscles, and lies to its outer side.

Branches of the External Maxillary Artery of the Neck

The **branches of the external maxillary artery in the neck** are:—(1) The ascending palatine; (2) the tonsillar; (3) the glandular; (4) the submental.

(1) The **ascending palatine** (figs. 410, 411)—the first branch of the external maxillary, but often a distinct branch of the external carotid—ascends between the internal and external carotids, and then between the stylo-glossus and stylo-pharyngeus muscles, and on reaching the wall of the pharynx is continued upwards between the superior constrictor and internal pterygoid muscles towards the base of the skull as high as the levator veli palatini, where it divides into two branches, a palatine and a tonsillar. One of these branches, the **palatine,** passes with the levator veli palatini over the curved upper margin of the superior constrictor to the soft palate, where it is distributed to the tissues constituting that structure, and anastomoses with its fellow of the opposite side and with the descending palatine branch of the internal maxillary, and the ascending pharyngeal, which vessel often to a great extent supplies the place of this artery. The other branch, the **tonsillar,** supplies the tonsil and the Eustachian tube, anastomosing with the tonsillar branch of the external maxillary (facial) and ascending pharyngeal arteries. The ascending palatine artery supplies the muscles between which it runs on its way to the palate.

(2) The **tonsillar branch** (fig. 411) ascends between the stylo-glossus and internal pterygoid muscles to the level of the tonsil, where it perforates the superior constrictor muscle of the pharynx, and ends in the tonsil, anastomosing with the tonsillar branch of the ascending palatine and with the other tonsillar arteries (fig. 410). It gives branches also to the root of the tongue.

(3) The **glandular** or **submaxillary branches** are distributed to the submaxillary gland as the artery is passing through or beneath that structure. A small twig from one of these branches usually supplies Wharton's duct.

(4) The **submental branch** (fig. 411) comes off from the external maxillary as the latter vessel lies under cover of the sub-maxillary gland, and, passing forwards on the mylo-hyoid muscle between the base of the jaw and the anterior belly of the digastricus, supplies these structures and the overlying platysma and integuments. It anastomoses with the sublingual artery. The external maxillary also supplies the adjacent muscles of the neck.

Branches of the External Maxillary Artery on the Face

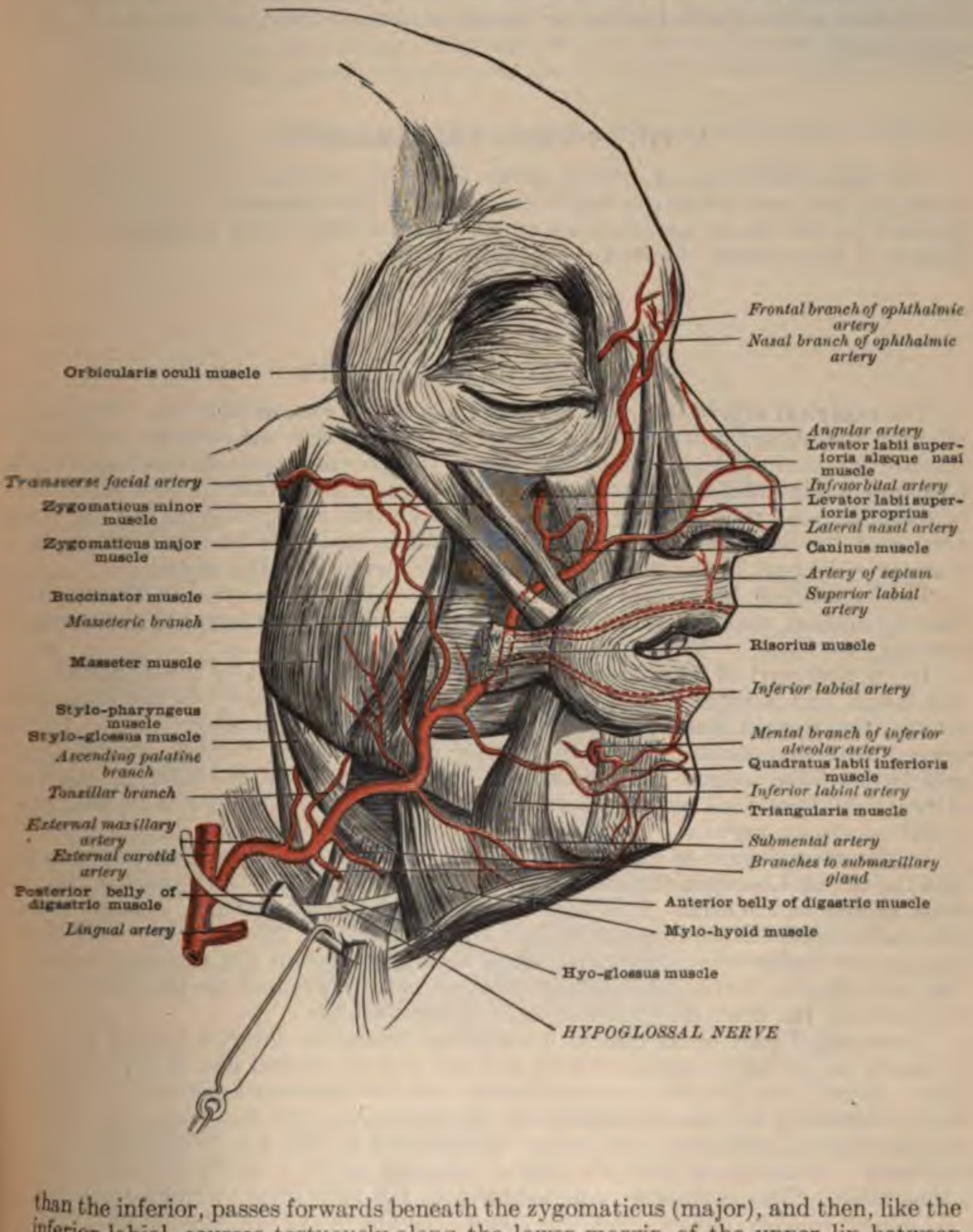
From the **outer** or **concave** side of the artery are given off branches which supply the masseter muscle and anastomose with the masseteric and buccinator branches of the internal maxillary artery, the transverse facial artery, and the infraorbital arteries.

From the **inner** or **convex** side the following larger and named vessels are given off:—(1) The inferior labial; (2) the superior labial; and (3) the angular.

(1) The **inferior labial (coronary) artery** arises at the angle of the mouth and runs in the under lip within the substance of the orbicularis oris, close to the mucous membrane. It anastomoses with the artery of the other side. Frequently an additional branch passes from the external maxillary to the lower lip.

(2) The **superior labial (coronary) artery,** arising from the facial a little higher than the inferior, passes forwards beneath the zygomaticus (major), and then, like the inferior labial, courses tortuously along the lower margin of the upper lip between the orbicularis oris and the mucous membrane, about 1·2 cm. (½ in.) from the junction of the mucous membrane and the skin. It is usually larger than the inferior labial. It anastomoses with its fellow of the opposite side, and gives off a small artery to the septum—**arteria septi nasi.** Compression of this vessel will sometimes control hæmorrhage from the nose.

FIG. 411.—SCHEME OF THE RIGHT EXTERNAL MAXILLARY ARTERY. (Walsham.)


Frontal branch of ophthalmic artery
Nasal branch of ophthalmic artery
Orbicularis oculi muscle
Angular artery
Levator labii superioris alæque nasi muscle
Infraorbital artery
Levator labii superioris proprius
Lateral nasal artery
Transverse facial artery
Zygomaticus minor muscle
Zygomaticus major muscle
Caninus muscle
Artery of septum
Superior labial artery
Buccinator muscle
Masseteric branch
Risorius muscle
Masseter muscle
Inferior labial artery
Stylo-pharyngeus muscle
Stylo-glossus muscle
Ascending palatine branch
Mental branch of inferior alveolar artery
Quadratus labii inferioris muscle
Tonsillar branch
Inferior labial artery
Triangularis muscle
External maxillary artery
External carotid artery
Submental artery
Branches to submaxillary gland
Posterior belly of digastric muscle
Anterior belly of digastric muscle
Lingual artery
Mylo-hyoid muscle
Hyo-glossus muscle
HYPOGLOSSAL NERVE

ing first downwards and then upwards over the lower border of the jaw immediately in front of the masseter muscle, where it is superficial, being merely covered by the integument and platysma. Here it can be felt beating, and can be readily compressed. In the above course it lies in the posterior part of the submaxillary triangle, and, in addition to the structures already mentioned as crossing it, is covered by the skin, superficial fascia, and platysma, and by one or two submaxillary lymphatic nodes. The vein is separated from the artery by the submaxillary gland, the posterior belly of the digastric muscle, the stylo-hyoid muscle, and the hypoglossal nerve.

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(2) The **tonsillar branch** (fig. 411) ascends between the stylo-glossus and internal pterygoid muscles to the level of the tonsil, where it perforates the superior constrictor muscle of the pharynx, and ends in the tonsil, anastomosing with the tonsillar branch of the ascending palatine and with the other tonsillar arteries (fig. 410). It gives branches also to the root of the tongue.

(3) The **glandular** or **submaxillary branches** are distributed to the submaxillary gland as the artery is passing through or beneath that structure. A small twig from one of these branches usually supplies Wharton's duct.

(4) The **submental branch** (fig. 411) comes off from the external maxillary as the latter vessel lies under cover of the sub-maxillary gland, and, passing forwards on the mylo-hyoid muscle between the base of the jaw and the anterior belly of the digastricus, supplies these structures and the overlying platysma and integuments. It anastomoses with the sublingual artery. The external maxillary also supplies the adjacent muscles of the neck.

Branches of the External Maxillary Artery on the Face

From the **outer** or **concave** side of the artery are given off branches which supply the masseter muscle and anastomose with the masseteric and buccinator branches of the internal maxillary artery, the transverse facial artery, and the infraorbital arteries.

BRANCHES OF THE OCCIPITAL ARTERY

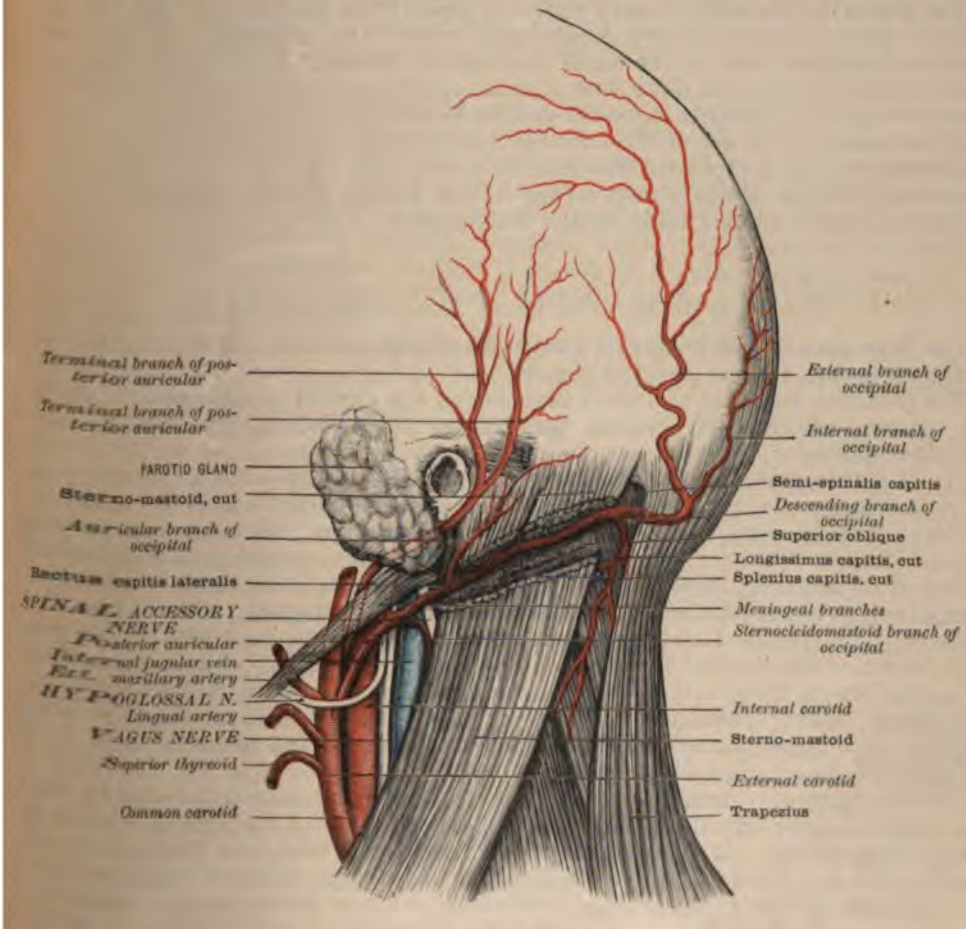
The branches of the occipital artery are:—(1) The muscular; (2) the meningeal; (3) the auricular; (4) the mastoid; (5) the descending; (6) the occipital.

(1) The **muscular branches** (fig. 412) supply the sternocleidomastoid and adjacent muscles. One of these branches may take the place of the sterno-mastoid branch of the external carotid. The hypoglossal nerve then, as a rule, loops round it instead of round the occipital.

(2) The **meningeal branches** (fig. 412), one or more in number, are long slender vessels which leave the occipital artery as it crosses the internal jugular vein and, ascending along that vessel, pass with it through the jugular foramen, and are distributed to the dura mater lining the posterior fossa of the skull.

(3) The **auricular branch** ascends over the mastoid process to the back of the ear, and supplies the pinna and concha. It sometimes takes the place of the posterior auricular artery (fig. 412).

FIG. 412.—SCHEME OF RIGHT OCCIPITAL AND POSTERIOR AURICULAR ARTERIES. (Walsham.)

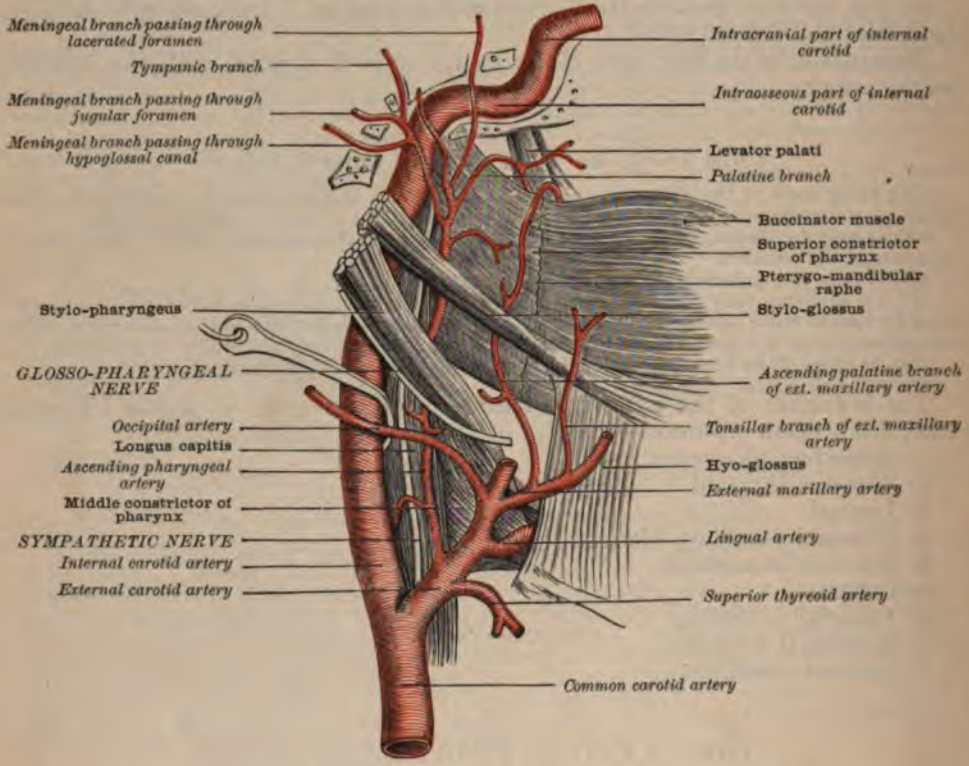

Terminal branch of posterior auricular
Terminal branch of posterior auricular
PAROTID GLAND
Sterno-mastoid, cut
Auricular branch of occipital
Rectus capitis lateralis
SPINAL ACCESSORY NERVE
Posterior auricular
Internal jugular vein
Ext. maxillary artery
HYPOGLOSSAL N.
Lingual artery
VAGUS NERVE
Superior thyreoid
Common carotid
External branch of occipital
Internal branch of occipital
Semi-spinalis capitis
Descending branch of occipital
Superior oblique
Longissimus capitis, cut
Splenius capitis, cut
Meningeal branches
Sternocleidomastoid branch of occipital
Internal carotid
Sterno-mastoid
External carotid
Trapezius

(4) The **mastoid branch** is a small twig that passes into the skull through the mastoid foramen, supplying the dura mater, the diploë, the walls of the lateral sinus, and the mastoid cells.

(5) The **descending** or **princeps cervicis** (fig. 412), the largest of the branches of the occipital, arises from that artery just before it emerges from beneath the splenius, and, descending for a short distance between the splenius and semi-spinalis capitis (complexus), divides into a superficial and a deep branch. The **superficial branch** perforates the splenius, supplies branches to the trapezius, and anas-

The **pharyngeal** branches supply the superior and middle constrictor muscles and the mucous membrane lining them. These vessels anastomose with branches of the superior thyreoid. One branch (the **palatine**) passes over the upper edge of the superior constrictor to the soft palate and its muscles. This branch follows a course similar to that taken by the ascending palatine artery, and when the latter is small may take its place. It generally gives off small twigs to the Eustachian tube and tonsil. The **tympanic** branches accompany the tympanic branch of the glosso-pharyngeal nerve through the tympanic canaliculus into the tympanum, and anastomose with the other tympanic arteries. The **posterior meningeal** branches are distributed to the membranes of the brain. Some of these pass with the jugular vein through the jugular foramen into the cranium, and supply the dura mater in the posterior fossa of the skull. Others occasionally reach the same fossa through the hypoglossal (anterior condyloid) canal in company with the hypoglossal nerve; while others pass through the cartilage of the lacerated foramen and supply the middle fossa of the skull.

FIG. 408.—SCHEME OF RIGHT ASCENDING PHARYNGEAL ARTERY. (Walsham.)
The internal carotid artery is hooked aside.


Meningeal branch passing through lacerated foramen
Tympanic branch
Meningeal branch passing through jugular foramen
Meningeal branch passing through hypoglossal canal
Stylo-pharyngeus
GLOSSO-PHARYNGEAL NERVE
Occipital artery
Longus capitis
Ascending pharyngeal artery
Middle constrictor of pharynx
SYMPATHETIC NERVE
Internal carotid artery
External carotid artery
Intracranial part of internal carotid
Intraosseous part of internal carotid
Levator palati
Palatine branch
Buccinator muscle
Superior constrictor of pharynx
Pterygo-mandibular raphe
Stylo-glossus
Ascending palatine branch of ext. maxillary artery
Tonsillar branch of ext. maxillary artery
Hyo-glossus
External maxillary artery
Lingual artery
Superior thyreoid artery
Common carotid artery

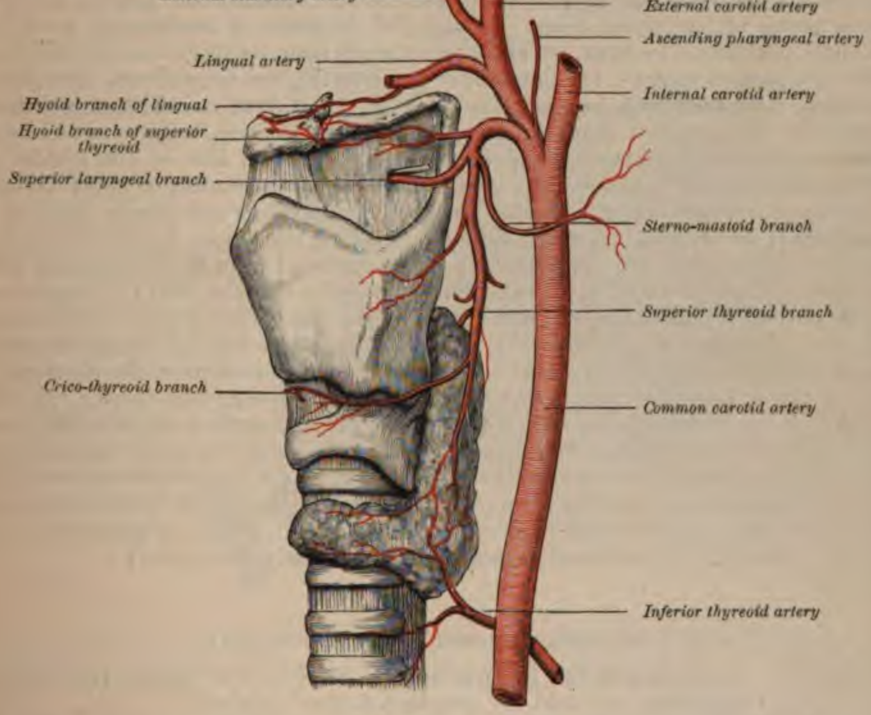
2. THE SUPERIOR THYREOID ARTERY

The **superior thyreoid artery** arises from the front of the external carotid a little above the origin of that vessel, and, coursing forwards, inwards, and then downwards, in a tortuous manner, supplies the depressor muscles of the hyoid bone, the larynx, the thyreoid body, and the lower part of the pharynx. The artery at first runs forwards and a little upwards, just beneath the greater cornu of the hyoid bone. In this part of its course it lies in the superior carotid triangle, and is quite superficial, being covered only with the integument, fascia, and platysma. It next turns downwards, and passes beneath the omo-hyoid, sterno-hyoid, and sterno-thyreoid muscles, and ends at the upper part of the thyreoid body by breaking up into branches, some of which pass downwards in front, and others behind the lateral lobe of the thyreoid to anastomose with ascending branches from the inferior thyreoid; whilst others, again, but much smaller in size, pass in the substance of the isthmus across the front of the trachea to anastomose with the superior thyreoid artery of the opposite side. These vessels, however, are so small that if the isthmus is divided accurately in the middle line, there is practically no arterial hæmorrhage. From the branch to the thyreoid body twigs are given off to the inferior constrictor and the upper part of the œsophagus. These anastomose with branches from the inferior thyreoid. The superior thyreoid vein passes beneath the artery on its way to the internal jugular vein. The superior thyreoid is the artery most commonly divided in cases of suicidal wounds of the throat.

BRANCHES OF THE SUPERIOR THYREOID ARTERY

The named **branches of the superior thyreoid artery** are:—(1) The hyoid; (2) the sterno-mastoid; (3) the superior laryngeal; and (4) the crico-thyreoid.

FIG. 409.—SCHEME OF LEFT SUPERIOR THYREOID ARTERY. (Walsham.)


External maxillary artery
External carotid artery
Ascending pharyngeal artery
Lingual artery
Internal carotid artery
Hyoid branch of lingual
Hyoid branch of superior thyreoid
Superior laryngeal branch
Sterno-mastoid branch
Superior thyreoid branch
Crico-thyreoid branch
Common carotid artery
Inferior thyreoid artery

(1) The **hyoid** is usually a small twig which passes along the lower border of the hyoid bone, lying on the thyreo-hyoid membrane under cover of the thyreo-hyoid and sterno-hyoid muscles. It supplies the infra-hyoid bursa and the thyreo-hyoid muscle, and anastomoses with its fellow of the opposite side, and with the hyoid branch of the lingual. When the latter artery is small, the hyoid branch of the superior thyreoid is usually comparatively large, and *vice versâ*.

(2) The **sterno-mastoid** (fig. 409) courses downwards and backwards across the carotid sheath, and entering the sterno-mastoid supplies the middle portion of that muscle. It gives off slender twigs to the thyreo-hyoid, sterno-hyoid, and omo-hyoid muscles, and the platysma and integuments covering it. At times the vessel arises directly from the external carotid. It lies usually somewhere in the upper part of the incision for tying the common carotid above the omo-hyoid muscle.

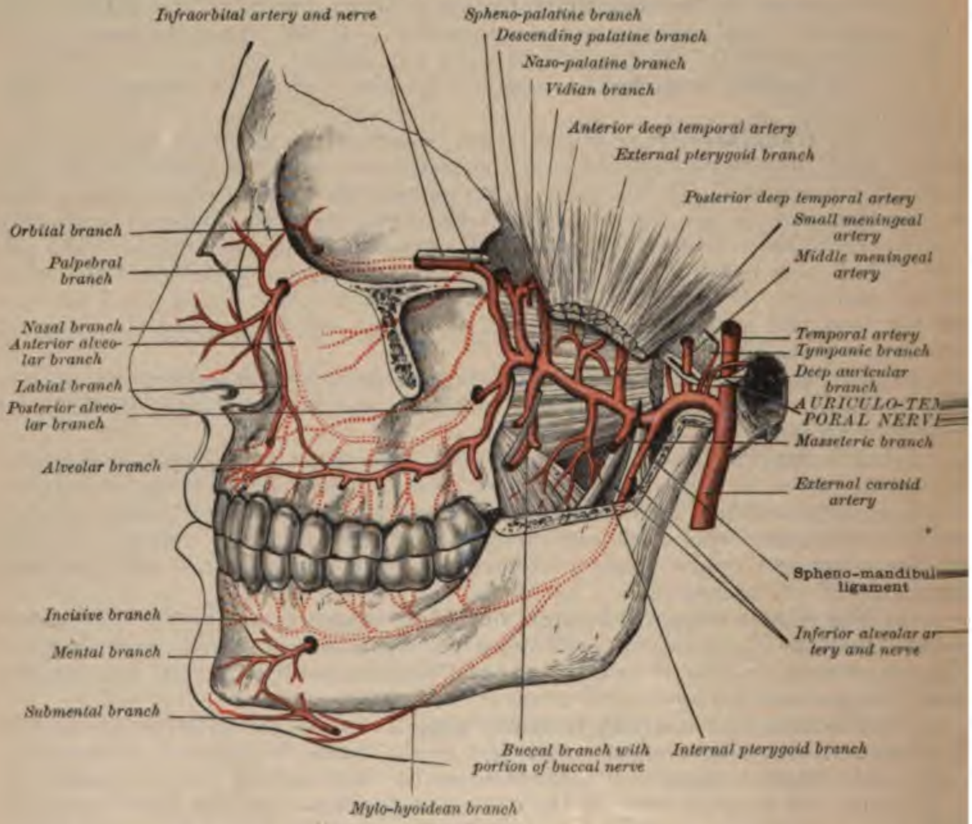
(3) The **superior laryngeal** (fig. 409) passes inwards and forwards beneath the thyreo-hyoid muscle, and, perforating the thyreo-hyoid membrane along with the superior laryngeal nerve, supplies the intrinsic muscles and mucous lining of the

breaks up into its terminal branches. It is divided into three portions: a mandibular, a pterygoid, and a pterygo-palatine.

(1) In the **first part of its course** (the **mandibular portion**) the artery lies between the neck of the jaw and the spheno-mandibular ligament, taking a horizontal course forwards and inwards parallel to and a little below the auriculo-temporal nerve and the external pterygoid muscle. It is here embedded in the deep portion of the parotid gland, and usually crosses in front of the inferior alveolar (dental) nerve.

(2) In the **second part of its course** (the **pterygoid portion**) the artery lies either between the two pterygoid muscles and the ramus of the jaw, and then turns upwards over the outer surface of the external pterygoid, beneath the temporal (spheno-maxillary) muscle to gain the two heads of the external pterygoid, between which it sinks into the pterygo-palatine fossa; or it passes behind and internal the external pterygoid, and is covered by that muscle till it reaches the interv between its two heads, where it then often forms a projecting loop as it turns in the pterygo-palatine fossa.

FIG. 413.—SCHEME OF LEFT INTERNAL MAXILLARY. (Walsham.)



Infraorbital artery and nerve
Spheno-palatine branch
Descending palatine branch
Naso-palatine branch
Vidian branch
Anterior deep temporal artery
External pterygoid branch
Posterior deep temporal artery
Small meningeal artery
Middle meningeal artery
Orbital branch
Palpebral branch
Nasal branch
Anterior alveolar branch
Labial branch
Posterior alveolar branch
Alveolar branch
Temporal artery
Tympanic branch
Deep auricular branch
AURICULO-TEM PORAL NERVE
Masseteric branch
External carotid artery
Spheno-mandibul ligament
Incisive branch
Mental branch
Inferior alveolar ar tery and nerve
Submental branch
Buccal branch with portion of buccal nerve
Internal pterygoid branch
Mylo-hyoidean branch

(3) In the **third part of its course** (the **pterygo-palatine portion**) the arte lies in the pterygo-palatine fossa beneath the maxillary division of the fifth ner and in close relationship with the spheno-palatine (Meckel's) ganglion, and th breaks up into its terminal branches.

BRANCHES OF THE INTERNAL MAXILLARY ARTERY

The **branches of the internal maxillary artery** are:—

(A) **From the first part**:—(1) The deep auricular; (2) the anterior tympa (3) the middle meningeal; (4) the inferior alveolar (dental); (5) the acces meningeal (sometimes). All these vessels pass through bony or cartilaginous canals.

(B) **From the second part**:—(1) The masseteric; (2) the posterior deep temporal; (3) the pterygoid; (4) the buccal; and (5) the anterior deep temporal. All these branches supply muscles.

(C) **From the third part**:—(1) The posterior superior alveolar (dental); (2) the infra-orbital; (3) the descending palatine; (4) the Vidian; and (5) the naso- or spheno-palatine. All these branches pass through bony canals.

BRANCHES OF THE FIRST PART OF THE INTERNAL MAXILLARY ARTERY

(1) The **deep auricular** (fig. 413) passes upwards in the substance of the parotid gland behind the capsule of the temporo-maxillary joint, and, perforating the bony or cartilaginous wall of the external auditory meatus, supplies the skin of that passage and the membrana tympani. It at times gives a branch to the joint as it passes behind the temporo-maxillary articular capsule.

(2) The **anterior tympanic branch** is a long slender vessel, which runs upwards behind the condyle of the jaw to the petro-tympanic (Glaserian) fissure, through which it passes to the interior of the tympanum. Here it supplies the lining membrane of that cavity and the levator tympani muscle, and anastomoses with the other tympanic arteries, forming with the tympanic branch of the stylo-mastoid artery a vascular circle around the membrana tympani. This circle is more distinct in the fœtus than in the adult.

(3) The **middle meningeal** is the largest branch of the internal maxillary artery. It comes off from that vessel as it lies between the spheno-mandibular ligament and the ramus of the jaw, and under cover of the external pterygoid passes directly upwards to the foramen spinosum, through which it enters the interior of the cranium. In this part of its course it is crossed by the chorda tympani nerve; and just before it enters the foramen is embraced by the two heads of origin of the auriculo-temporal nerve (fig. 413).

The trunk of the mandibular division of the fifth nerve, as the latter emerges through the foramen ovale, lies in front of the artery. As the artery passes upwards it is surrounded by filaments of the sympathetic nerve, and is accompanied by two veins which open into the internal maxillary vein. On entering the skull it ramifies between the bone and dura mater, supplying both structures. It at first ascends for a short distance in a groove on the greater wing of the sphenoid, and then divides into two branches, an anterior and a posterior.

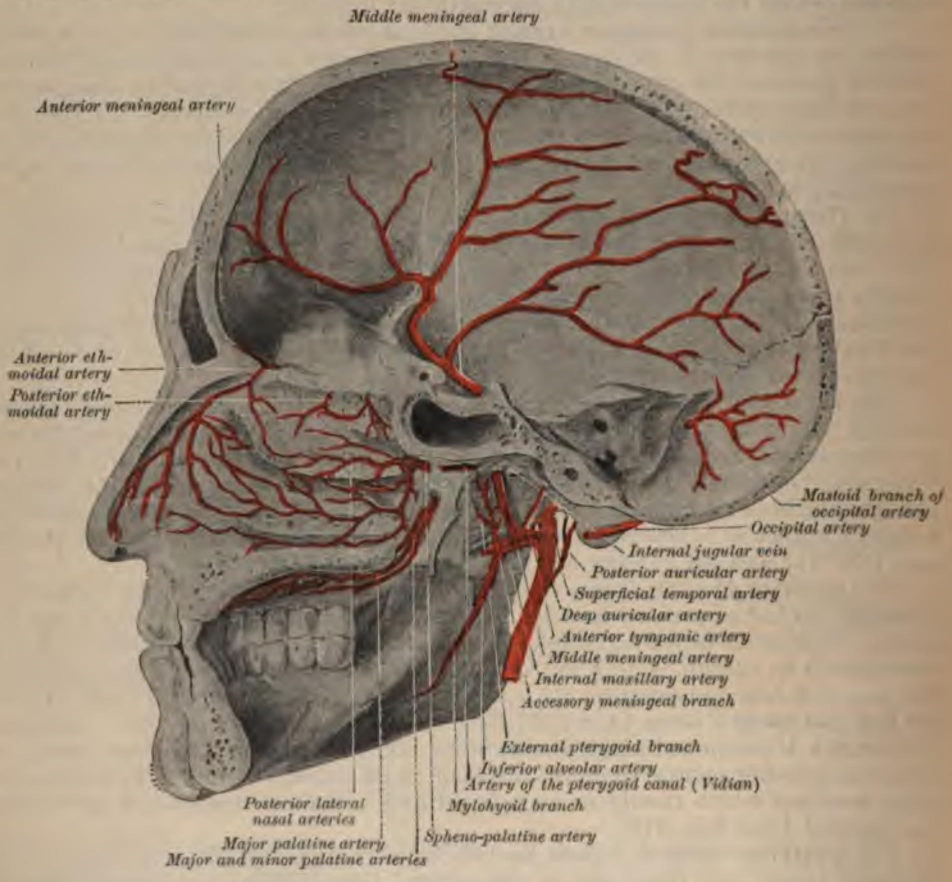
The **anterior branch** passes upwards, in the groove on the greater wing of the sphenoid, on to the parietal bone at its anterior and inferior angle; at this spot the groove becomes deepened and often bridged over by a thin plate of bone, being converted for 6 to 12 mm. (¼ to ½ in.) or more into a distinct canal. The situation of the artery is here indicated on the exterior of the skull by a spot 3·7 cm. (1½ in.) behind, and about 2·5 cm. (1 in.) above, the external angle of the orbit. The anterior branch is continued along the anterior border of the parietal bone nearly as far as the superior sagittal sinus, and gives off in its course, but especially posteriorly, large branches which ramify in an upward and backward direction in grooves on the parietal bone (fig. 414).

The **posterior branch** passes backwards over the squamous portion of the temporal bone; and thence on to the parietal bone, behind the anterior branch. This branch and its collaterals extend upwards as far as the sagittal sinus, and backwards as far as the transverse (lateral) sinus.

In addition to its terminal anterior, and terminal posterior branches, the middle meningeal gives off:—(*a*) **Gasserian branches** to the Gasserian ganglion and Meckel's space. (*b*) A **petrosal branch,** which enters the hiatus of the facial canal in company with the large superficial petrosal nerve and anastomoses with the terminal branch of the stylo-mastoid artery. (*c*) A **tympanic branch,** which enters the canal for the tensor tympani, and supplies that muscle. (*d*) An **orbital** or **lachrymal branch,** which enters the orbit at the outermost part of the superior orbital (sphenoidal) fissure, or sometimes through a minute foramen, just external to that fissure, and anastomoses with the lachrymal branch of the ophthalmic. (*e*) **Anastomotic** or **perforating branches** which pierce the greater wing of the sphenoid bone, and anastomose with the deep temporal arteries.

(4) The **inferior alveolar (dental) artery** (fig. 413), arising from the internal maxillary as it lies between the spheno-mandibular ligament and neck of the jaw, courses downwards to the mandibular foramen, which it enters in company with, and a little behind and external to, the inferior alveolar nerve. It then passes along the canal in the interior of the bone, giving off branches to the molar, bicuspid, and canine teeth. On reaching the mental foramen it divides into two branches, the incisive and the mental. The **incisive** continues its course in the bone, supplies branches to the incisor teeth, and anastomoses with the artery of the opposite side. The **mental** passes through the mental foramen in company with the mental branch of the inferior alveolar (dental) nerve, and emerges on the chin under cover of the quadratus labii inferioris. It anastomoses above with the inferior labial (coronary), and below with the submental, and also with the inferior labial. Near its origin the artery gives off (*a*) a **lingual** or **gustatory branch,** which accompanies and supplies the lingual nerve, and ends in the mucous membrane of the mouth; and, just before it enters the mandibular (dental) foramen in the lower jaw, (*b*) a **mylo-hyoidean branch,** which accompanies the nerve of that name along the groove in the lower jaw, and, after supplying the mylo-hyoid muscle, anastomoses with the sublingual and submental arteries.

FIG. 414.—THE MIDDLE MENINGEAL ARTERY WITHIN THE SKULL. (After Spalteholz.)


Middle meningeal artery
Anterior meningeal artery
Anterior ethmoidal artery
Posterior ethmoidal artery
Mastoid branch of occipital artery
Occipital artery
Internal jugular vein
Posterior auricular artery
Superficial temporal artery
Deep auricular artery
Anterior tympanic artery
Middle meningeal artery
Internal maxillary artery
Accessory meningeal branch
External pterygoid branch
Inferior alveolar artery
Artery of the pterygoid canal (Vidian)
Mylohyoid branch
Spheno-palatine artery
Posterior lateral nasal arteries
Major palatine artery
Major and minor palatine arteries

(5) The **accessory (small) meningeal** arises either from the internal maxillary a little in front of the middle meningeal, or as a branch of the latter vessel. It passes upwards along the course of the mandibular division of the fifth nerve, and, entering the skull through the foramen ovale, is distributed to the Gasserian ganglion, and to the walls of the cavernous sinus and the dura mater in the neighbourhood.

BRANCHES OF THE SECOND PART OF THE INTERNAL MAXILLARY ARTERY

The branches of the second portion of the internal maxillary all supply muscles. They are:—(1) The masseteric; (2) the posterior deep temporal; (3) the pterygoid; (4) the buccal; and (5) the anterior deep temporal.

(1) The **masseteric branch** comes off from the internal maxillary as the latter is passing from between the neck of the jaw and the spheno-mandibular ligament. It is directed outwards along with the masseteric nerve, and, passing through the mandibular (sigmoid) notch in the lower jaw, supplies the masseter muscle. Some filaments perforate the muscle and anastomose with the transverse facial and with the masseteric branches of the external maxillary (facial).

(2) The **posterior deep temporal** arises, as a rule, from the internal maxillary in common with the masseteric for a little beyond that branch. It passes upwards beneath the temporal muscle in a slight groove on the anterior margin of the squamous portion of the temporal bone, supplying the temporal muscle, the pericranium, and the external layer of the bone. It anastomoses with the anterior deep temporal and the other temporal arteries.

(3) The **pterygoid branches** are short trunks which pass into and supply the internal and external pterygoid muscles.

(4) The **buccal branch** (fig. 413) courses forwards and downwards with the buccal nerve to the buccinator muscle, lying in close contact with the inner side and anterior margin of the tendon of the temporal muscle and coronoid process of the lower jaw. It supplies the buccinator muscle and mucous membrane of the mouth, and anastomoses with the external maxillary (facial), transverse facial, and infraorbital arteries.

(5) The **anterior deep temporal branch** ascends beneath the temporal muscle in a slight groove on the greater wing of the sphenoid bone. It supplies the muscle, pericranium, and subjacent bone, and gives off small branches which pass through minute foramina in the zygomatic (malar) bone. Some of these last branches enter the orbit and anastomose with the lachrymal artery; others emerge on the face and anastomose with the transverse facial artery.

BRANCHES OF THE THIRD PART OF THE INTERNAL MAXILLARY ARTERY

The branches of the third part of the internal maxillary artery, like those of the first part, all pass through bony canals. They are the following:—(1) The posterior superior alveolar (dental); (2) the infraorbital; (3) the descending palatine; (4) the artery of the pterygoid canal (Vidian); (5) the pterygo-palatine; and (6) the spheno-palatine.

(1) The **posterior superior alveolar (dental) branch** arises from the internal maxillary as the latter is passing into the pterygo-palatine (spheno-maxillary) fossa, and descends in a tortuous manner in a groove on the back of the body of the maxilla. It gives off branches to the maxillary sinus, to the molar and bicuspid teeth, the gums, and to the buccinator muscle.

(2) The **infraorbital branch** arises from the internal maxillary, generally as a common trunk with the posterior alveolar (dental). It passes forwards and a little upwards through the pterygo-palatine (spheno-maxillary) fossa; then forwards in company with the maxillary division of the fifth nerve, first along the groove, and then through the canal in the orbital plate of the maxilla; and finally, emerging on the face at the infraorbital foramen, under cover of the quadratus labii superioris, is distributed to the structures forming the upper lip, the lower eyelid, the lachrymal sac, and the side of the nose. It anastomoses with the superior labial (coronary) and angular branches of the external maxillary (facial), with the nasal and lachrymal branches of the ophthalmic, and with the transverse facial. It gives off small branches supplying the fat of the orbit and the inferior rectus and inferior oblique muscles. The **anterior superior alveolar (dental) branch** passes downwards through a groove in the anterior wall of the maxilla, together with the anterior alveolar (dental) branch of the infraorbital nerve, and supplies branches to the incisor and canine teeth and the mucous membrane of the maxillary sinus. It has also **nasal branches** which pass through the foramina in the nasal process of the maxilla.

(3) The **descending palatine branch** descends in the posterior palatine canal

with the anterior palatine branch of the spheno-palatine ganglion. On emerging on the palate at the greater (posterior) palatine foramen, it divides into the following branches:—(*a*) An **anterior major branch,** which courses forwards in the muco-periosteum at the junction of the hard palate with the alveolar process as far as the incisive (anterior palatine) foramen, where it anastomoses with the naso-palatine artery; and (*b*) **posterior minor branches,** which pass backwards and downwards into the soft palate, contributing to the supply of that structure, and anastomosing with the ascending palatine artery. After the operation for cleft palate, serious hæmorrhage occasionally occurs from the descending palatine artery. It may be stopped by compressing the artery by means of a plug inserted in the greater (posterior) palatine foramen. The foramen is situated a little behind, and internal to, the last molar tooth, and almost immediately in front of the hamular process.

(4) The **Vidian artery** is a long slender branch which passes backwards through the pterygoid (Vidian) canal in company with the Vidian nerve into the cartilage of the lacerated foramen. It gives off branches which supply the roof of the pharynx, and anastomose with the ascending pharyngeal and spheno-palatine arteries; also a branch which is distributed to the Eustachian tube; and one which enters the tympanum, and anastomoses with the other tympanic arteries.

(5) The **spheno-palatine,** the terminal branch of the internal maxillary, passes with the naso-palatine branch of the spheno-palatine ganglion from the pterygopalatine (spheno-maxillary) fossa into the nose through the spheno-palatine foramen. Crossing the roof of the nose in the muco-periosteum, it passes on to the septum, and then runs forwards and downwards in a groove on the vomer (under the name of the **naso-palatine,** or **artery of the septum**) towards the incisive (anterior palatine) foramen, where it anastomoses with the anterior palatine artery, which enters the nose through the lateral compartment of that foramen (the canal of Stenson). In this course it gives off branches to the roof and contiguous portions of the pharynx, and to the sphenoidal cells. It has also **nasal branches,** which ramify over the nasal conchæ (turbinate bones) and lateral walls of the nose, and give twigs to the ethmoidal and frontal sinuses and the lining membrane of the maxillary sinus; and **septal branches,** which run upwards and forwards, giving small twigs to the mucous membrane covering the upper part of the septum, and which pass through the cribriform plate of the ethmoid, and anastomose with the ethmoidal arteries (perforating or meningeal branches).

THE INTERNAL CAROTID ARTERY

The **internal carotid** (figs. 415 and 416) arises with the external carotid at the bifurcation of the common carotid, opposite the upper border of the thyreoid cartilage, on a level with the fourth cervical vertebra. It is at first placed a little external to the external carotid, but as it ascends in the neck the external carotid becomes more superficial and in front of the internal. The internal carotid passes up the neck, in front of the transverse processes of the upper cervical vertebræ, lying upon the longus capitis (rectus capitis major), to the carotid foramen, thence through the carotid canal in the petrous portion of the temporal bone, making at first a turn forwards and inwards and then a second turn upwards, and enters the cranium through the foramen lacerum. It then makes a sigmoid curve on the side of the body of the sphenoid bone, and terminates, after perforating the dura mater, by dividing opposite the anterior clinoid processes in the lateral fissure (fissure of Sylvius), into the anterior and middle cerebral arteries.

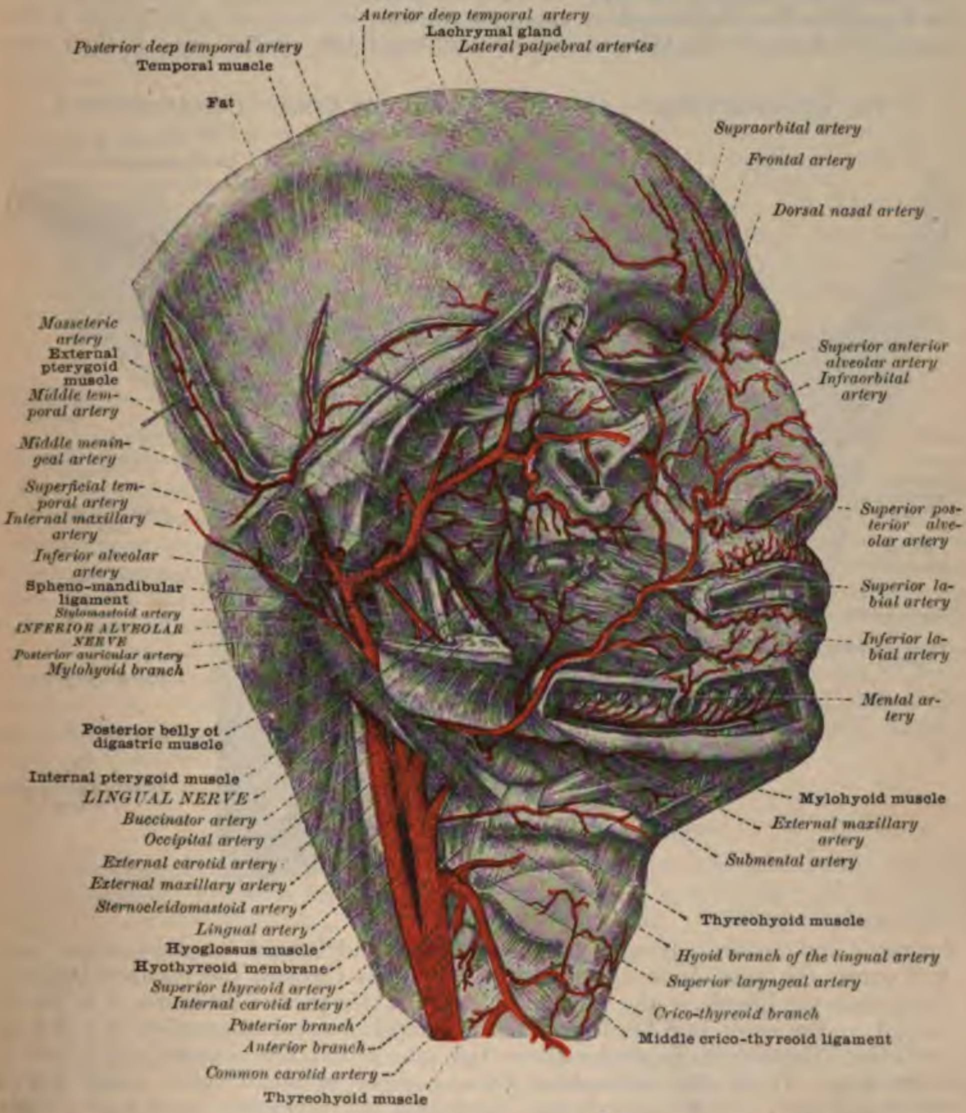
In its course up the neck it often forms one or more curves, especially in old people. Between the internal and the external carotids, at their angle of divergence, is situated the intercarotid body, or ganglion intercaroticum.

The internal carotid is the continuation upwards of the primitive dorsal aorta, and supplies the greater part of the brain, the contents of the orbit, and parts of the internal ear, forehead, and nose. It is divided into three portions;—(1) a cervical; (2) an intraosseous, or petrosal; and (3) an intracranial.

1. The Cervical Portion

Relations.—In the neck (fig. 415) the artery is at first comparatively superficial, having **in front** of it, as it lies in the superior carotid triangle, the skin, superficial fascia, platysma and deep fascia, and the overlapping edge of the sterno-mastoid muscle. Higher up, as it sinks beneath the parotid gland, it becomes deeply placed, and is crossed by the posterior belly of the digastric and stylo-hyoid muscles, the hypoglossal nerve, and the occipital and posterior auricular arteries; whilst still higher it is separated from the external carotid artery, which here gets in front of it, by the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus nerve, and by the stylo-hyoid ligament.

Fig. 415.—The Carotid Arteries. (After Toldt, "Atlas of Human Anatomy," Rebman London and New York.)



Anterior deep temporal artery
Lachrymal gland
Lateral palpebral arteries
Posterior deep temporal artery
Temporal muscle
Fat
Supraorbital artery
Frontal artery
Dorsal nasal artery
Masseteric artery
External pterygoid muscle
Middle temporal artery
Middle meningeal artery
Superficial temporal artery
Internal maxillary artery
Inferior alveolar artery
Spheno-mandibular ligament
Stylomastoid artery
INFERIOR ALVEOLAR NERVE
Posterior auricular artery
Mylohyoid branch
Superior anterior alveolar artery
Infraorbital artery
Superior posterior alveolar artery
Superior labial artery
Inferior labial artery
Mental artery
Posterior belly of digastric muscle
Internal pterygoid muscle
LINGUAL NERVE
Buccinator artery
Occipital artery
External carotid artery
External maxillary artery
Sternocleidomastoid artery
Lingual artery
Hyoglossus muscle
Hyothyreoid membrane
Superior thyreoid artery
Internal carotid artery
Posterior branch
Anterior branch
Common carotid artery
Thyreohyoid muscle
Mylohyoid muscle
External maxillary artery
Submental artery
Thyreohyoid muscle
Hyoid branch of the lingual artery
Superior laryngeal artery
Crico-thyreoid branch
Middle crico-thyreoid ligament

Behind, it lies upon the longus capitis (rectus capitis anterior major), which separates it from the transverse processes of the three upper cervical vertebræ, on the superior cervical ganglion of the sympathetic nerve, and on the vagus nerve. Near the base of the skull, the hypoglossal, vagus, glosso-pharyngeal, and spinal accessory nerves cross obliquely behind it, separating it at this spot from the internal jugular vein, which, as the artery is about to enter the carotid canal, also forms one of its posterior relations.

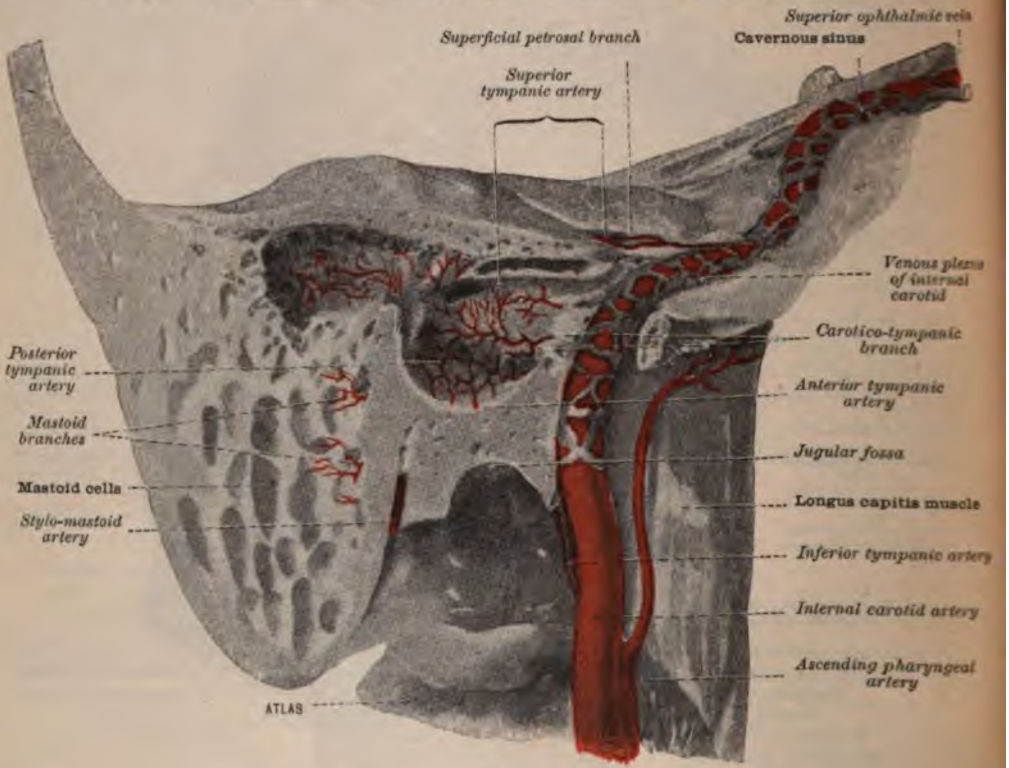
On its **outer side** are the internal jugular vein and vagus nerve.

On its **inner side** it is in relation with the pharynx, the superior constrictor muscle separating it from the tonsil. The ascending pharyngeal and ascending palatine arteries, and at the base of the skull the Eustachian tube and levator palati muscle, are also internal to it.

2. THE INTRAOSSEOUS OR PETROSAL PORTION

The **intraosseous portion** (fig. 416) is situated in the carotid canal in the petrous portion of the temporal bone. It is here separated from the walls of the canal by a prolongation downwards of the dura mater. In this part of its course it first ascends in front of the tympanum and cochlea of the internal ear; it then turns forwards and inwards, lying a little internal to and behind the Eustachian tube, and enters the cranial cavity by turning upwards through the foramen lacerum, lying upon the lingula of the sphenoid bone. In this part of its course it is accompanied by the ascending branches from the superior cervical ganglion of the sympathetic. These form a plexus about the artery, but are situated chiefly on its outer side. It is also surrounded by a number of small veins, which receive tributaries from the tympanum and open into the cavernous sinus and internal jugular vein.

FIG. 416.—THE INTERNAL CAROTID ARTERY IN THE CANAL. (After Spalteholz.)


Superior ophthalmic vein
Superficial petrosal branch
Cavernous sinus
Superior tympanic artery
Venous plexus of internal carotid
Carotico-tympanic branch
Posterior tympanic artery
Anterior tympanic artery
Mastoid branches
Jugular fossa
Mastoid cells
Longus capitis muscle
Stylo-mastoid artery
Inferior tympanic artery
Internal carotid artery
Ascending pharyngeal artery
ATLAS

3. THE INTRACRANIAL PORTION

On entering the cranium through the foramen lacerum, the internal carotid first ascends towards the posterior clinoid process, but soon changing its direction, it curves forwards and slightly downwards by the side of the body of the sphenoid bone on the inner wall of the cavernous sinus (fig. 416). Here it has the sixth nerve immediately external to it, and is covered by the lining membrane of the sinus. Again turning upwards, it pierces the dura mater on the inner side of the anterior clinoid process, and, passing between the second and third nerves to the anterior perforated space at the inner end of the lateral (Sylvian) fissure, divides into its two terminal branches, the anterior and middle cerebral. After it has perforated the dura mater it is described by some anatomists as a fourth portion—the intracerebral (fig. 417). As it lies in the foramen lacerum the artery is crossed on its outer side by the great superficial petrosal nerve as the latter goes to join the great deep petrosal from the carotid plexus to form the Vidian nerve.

BRANCHES OF THE INTERNAL CAROTID ARTERY

The **cervical portion** gives off no branch. The **intraosseous portion** gives off:—(1) caroticotympanic. The **intracranial portion** gives off:—(1) ophthalmic; (2) posterior communicating; (3) chorioid; (4) anterior cerebral; (5) middle cerebral.

Branches of the Intraosseous Portion.—(1) The **caroticotympanic** enters the tympanum through a small foramen in the posterior wall of the carotid canal, and contributes its quota to the blood-supply of that cavity. It anastomoses with the tympanic branches of the stylo-mastoid and internal maxillary arteries.

Branches of the Intracranial Portion.—As the internal carotid artery lies on the inner side of the cavernous sinus, it gives off the following small branches—(1) branches to the walls of the cavernous sinus; (2) to the pituitary body; (3) to the Gasserian ganglion; (4) to the dura mater; these anastomose with anterior branches of the middle meningeal.

Opthalmic arteries

(1) THE OPHTHALMIC ARTERY

The **ophthalmic artery** (fig. 417) comes off from the internal carotid immediately below the anterior clinoid process just as the latter vessel is passing through the dura mater. Entering the orbit through the optic foramen below and external to the optic nerve, it at once perforates the sheath of dura mater which is prolonged through the optic foramen on both artery and nerve. It then runs in a gentle curve with its convexity outwards below the optic nerve and external rectus, being here crossed by the naso-ciliary (nasal) nerve, and turning forwards, inwards, and upwards, passes over the optic nerve, around which it thus forms a loop (fig. 417), to the inner side of the orbit. Thence it runs obliquely beneath the superior rectus in front of the naso-ciliary (nasal) nerve under the lower border of the superior oblique, but above the internal rectus, and continues its course under the pulley for the superior oblique and reflected tendon of that muscle to the internal angle of the orbit, where it divides into the frontal and nasal branches.

BRANCHES OF THE OPHTHALMIC ARTERY

The **branches of the ophthalmic artery** are:—(*a*) the lachrymal; (*b*) the supra-orbital; (*c*) the central artery of the retina; (*d*) the muscular; (*e*) the ciliary; (*f*) the posterior ethmoidal; (*g*) the anterior ethmoidal; (*h*) the medial palpebral; (*i*) the frontal; and (*k*) the dorsal nasal.

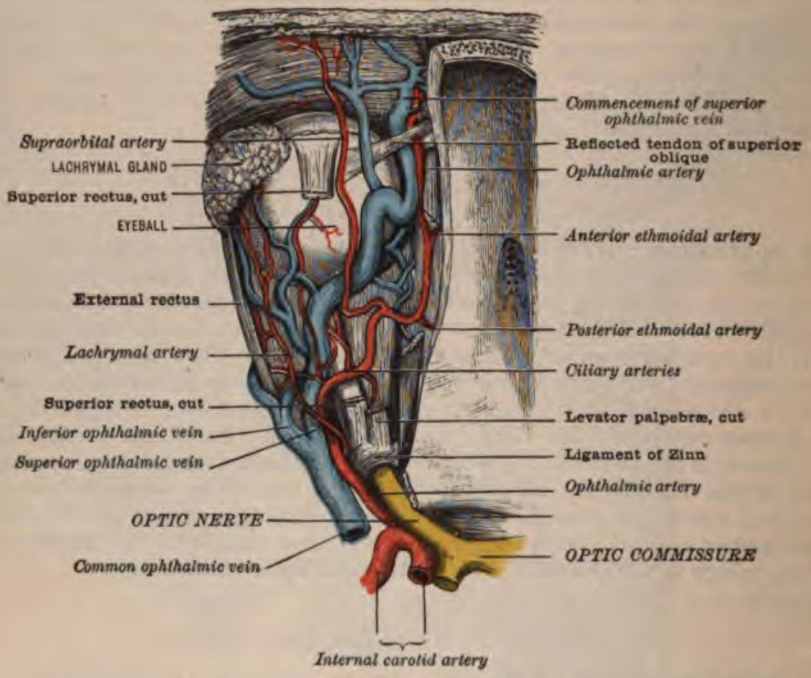
(*a*) THE LACHRYMAL ARTERY

The **lachrymal artery** is usually the first and at times the largest branch of the ophthalmic. It arises between the superior and external rectus on the outer side of the optic nerve from the ophthalmic, soon after that vessel has entered the orbit. At times it is given off from the ophthalmic outside the orbit, and then usually passes into that cavity through the superior orbital (sphenoidal) fissure. It runs forwards along the outer wall of the orbit with the lachrymal nerve, above the upper border of the external rectus, to the lachrymal gland, which it supplies. In this course it furnishes the following branches:—(i) **Recurrent lachrymal,** one or more branches which pass backwards through the superior orbital (sphenoidal) fissure, and anastomose with the lachrymal branch of the middle meningeal artery. The anastomosis is sometimes of large size, and then takes the chief share in the formation of the lachrymal artery. (ii) **Muscular branches,** distributed chiefly to the external rectus. (iii) **Malar branches**—small twigs, which pass through the zygomatico-orbital (malar) canals, and anastomose with the orbital branch of the middle temporal, and with the transverse facial on the cheek. (iv) **Lateral palpebral branches,** which are distributed to the upper and lower eyelids and to the conjunctiva. (v) **Ciliary.** See CILIARY ARTERIES, page 537.

(b) THE SUPRAORBITAL ARTERY

The **supraorbital artery** usually arises from the ophthalmic as the latter vessel is about to cross over the optic nerve. Passing upwards to the inner side of the superior rectus and levator palpebræ, it runs along the upper surface of the latter muscle with the frontal nerve in the orbital fat, but beneath the periosteum, to the supraorbital notch. On emerging on the forehead beneath the orbicularis oculi, it divides into a superficial and deep branch, the former ramifies between the skin and epicranius (occipito-frontalis), the latter between the epicranius and the pericranium. Both branches anastomose with the anterior branches of the superficial temporal, the angular branch of the external maxillary (facial), and the transverse facial artery. The branches of the supraorbital are:—(i) **Periosteal,** to the periosteum of the roof of the orbit; (ii) **muscular,** to the levator palpebræ and superior rectus; (iii) **diploic,** given off as the artery is passing through the supraorbital notch and, entering a minute foramen at the bottom of the notch, is distributed to the diploë and frontal sinuses; (iv) **trochlear,** to the pulley of the superior oblique; (v) **palpebral,** to the upper eyelid.

FIG. 417.—THE LEFT OPHTHALMIC ARTERY AND VEIN.


Commencement of superior ophthalmic vein
Supraorbital artery
Reflected tendon of superior oblique
LACHRYMAL GLAND
Ophthalmic artery
Superior rectus, cut
EYEBALL
Anterior ethmoidal artery
External rectus
Posterior ethmoidal artery
Lachrymal artery
Ciliary arteries
Superior rectus, cut
Levator palpebræ, cut
Inferior ophthalmic vein
Ligament of Zinn
Superior ophthalmic vein
Ophthalmic artery
OPTIC NERVE
OPTIC COMMISSURE
Common ophthalmic vein
Internal carotid artery

(c) THE CENTRAL ARTERY OF THE RETINA

The **arteria centralis retinæ,** a small but constant branch, comes off from the ophthalmic close to the optic foramen, and, perforating the optic nerve abo 6 mm. (¼ in.) behind the globe, runs forwards in the substance of the nerve to t eyeball, supplying the retina. The fact that this artery penetrates the substa of the optic nerve is of developmental interest, as it indicates the posterior extre ity of the chorioidal fissure. Its further description is given in the Anatomy of the Eye.

(*d*) THE MUSCULAR BRANCHES

The **muscular branches** are very variable in their origin and distribution. They may be roughly divided into superior and inferior sets. The superior or smaller set supply the superior oblique, the levator palpebræ, and superior rectus. The inferior pass forward, between the optic nerve and the inferior rectus, supplying that muscle, the internal rectus, and the inferior oblique. From the muscular branches are given off the anterior ciliary arteries. (See Ciliary Arteries.)

(*e*) THE CILIARY ARTERIES

The **ciliary arteries** are divided into three sets:—The **short posterior,** the **long posterior,** and the **anterior.** (i) The **short posterior,** five or six in number, come off chiefly from the ophthalmic as it is crossing the optic nerve. They run forwards about the nerve, dividing into twelve or fifteen small vessels, which perforate the sclerotic around the entrance of the optic nerve, and are distributed to the chorioid coat. (ii) The **long posterior** ciliary arteries, usually two, sometimes three, in number, come off from the ophthalmic on either side of the optic nerve, and run forwards with the short ciliary to the sclerotic. On piercing the sclerotic, they course forwards, one on either side in the equatorial line, between that coat and the chorioid to the ciliary processes and iris. Their further distribution is given under the Anatomy of the Eye. (iii) The **anterior ciliary** are derived from the muscular branches and from the lachrymal. They run to the globe along the tendons of the recti, forming a zone of radiating vessels beneath the conjunctiva. A part of them (the **episcleral arteries**) perforate the sclerotic about 6 mm. (¼ in.) behind the cornea, and supply the iris and ciliary processes. It is these vessels that are enlarged and congested in iritis, forming the circumcorneal zone of redness so characteristic of that disease. They then differ from the tortuous vessels of the conjunctiva in that they are straight and parallel. The remainder constitute the **anterior conjunctival** arteries.

(*f*) THE POSTERIOR ETHMOIDAL ARTERY

The **posterior ethmoidal** (fig. 417) runs inwards between the superior oblique and internal rectus, and, leaving the orbit by the posterior ethmoidal canal, together with the posterior ethmoidal branch of the naso-ciliary (nasal) nerve, enters the posterior ethmoidal cells, whence it passes through a transverse slit-like aperture between the sphenoid bone and cribriform plate of the ethmoid bone into the cranium. It gives off (i) **ethmoidal branches** to the posterior ethmoidal cells; (ii) **meningeal branches** to the dura mater lining the cribriform plate; and (iii) **nasal branches,** which pass through the cribriform plate to the superior meatus and upper spongy bones of the nose, and anastomose with the nasal branches of the spheno-palatine artery (fig. 414).

(*g*) THE ANTERIOR ETHMOIDAL ARTERY

The **anterior ethmoidal** (fig. 414), a larger branch than the posterior ethmoidal, arises in front of the latter, passes inwards between the superior oblique and internal rectus, and, leaving the orbit through the anterior ethmoidal canal, in company with the anterior ethmoidal nerve, enters the cranial cavity. After running a short distance beneath the dura mater on the cribriform plate of the ethmoid bone, it passes into the nose through the horizontal slit-like aperture by the side of the crista galli. Its terminal branch passes along the groove on the under surface of the nasal bone, and emerges on the nose between the bone and lateral cartilage, terminating in the skin of that organ. It gives off the following branches in its course:—(i) **Ethmoidal,** to the anterior ethmoidal cells; (ii) **meningeal,** to the dura mater of the anterior fossa; (iii) **nasal,** to the middle meatus and anterior part of the nose; (iv) **frontal,** to the frontal sinuses; (v) **cutaneous,** or **terminal,** to the skin of the nose.

(*h*) The Medial Palpebral Branches

The **medial palpebral branches** arise either separately or by a common trunk from the ophthalmic artery opposite the pulley for the superior oblique, just as the latter vessel is about to divide into its terminal branches. They pass, one above and one below, the internal palpebral ligament or tendo-oculi, and then skirt along the upper and lower eyelids respectively, near the free margin between the tarsal cartilages and the orbicularis muscle, and form a **superior** and an **inferior tarsal arch** by anastomosing with the lateral palpebral branches of the lachrymal. The upper also anastomoses with the supraorbital artery and orbital branch of the temporal artery; the lower with the infraorbital, the angular branch of the external maxillary (facial), and the transverse facial arteries. A branch from the lower palpebral passes with the nasal duct as far as the inferior meatus. Small twigs, the **posterior conjunctival arteries,** are also given to the caruncula lachrymalis and conjunctiva.

(*i*) The Frontal Branch

The **frontal branch,** the upper of the terminal branches of the ophthalmic, pierces the superior tarsus at the inner angle of the orbit, passes upwards over the frontal bone, beneath the orbicularis oculi, supplies the structures in its neighbourhood, and anastomoses with its fellow of the opposite side, with the supraorbital, and with the anterior division of the superficial temporal artery.

(*k*) The Dorsal Nasal Branch

The **dorsal nasal,** the lower of the terminal branches of the ophthalmic, leaves the orbit at the inner canthus by perforating the tarsus above the internal palpebral ligament. It then descends along the dorsum of the nose, beneath the integuments, and anastomoses with the angular and lateral nasal branches of the external maxillary (facial). It gives off a **lachrymal branch** as it crosses the lachrymal sac, and a **transverse nasal branch** as it crosses the root of the nose; the latter vessel anastomoses with its fellow of the opposite side.

(2) THE POSTERIOR COMMUNICATING ARTERY

The **posterior communicating artery** (fig. 418) is given off from the internal carotid just before the division of that vessel into the anterior and middle cerebral arteries; occasionally it arises from the middle cerebral itself. It is as a rule a slender vessel which runs backwards over the optic tract and crus cerebri along the side of the hippocampal gyrus to join the posterior cerebral. At times, however, it is of considerable size, and contributes chiefly to form the posterior cerebral, the portion of the latter vessel between the basilar and posterior communicating being then as a rule reduced to a mere rudiment. It gives off the following branches:—(*a*) the **hippocampal,** to the convolution of that name; and (*b*) the **middle thalamic,** to the optic thalamus.

(3) THE CHORIOID ARTERY

The **chorioid** is a small but constant vessel which arises as a rule from the back part of the internal carotid just external to the origin of the posterior communicating. It passes backwards on the optic tract and the crus cerebri, at first lying parallel and a little external to the posterior communicating artery, and then, turning slightly outwards, dips under the edge of the uncinate convolution, and, entering the transverse fissure at the lower end of the descending cornu of the lateral ventricle, ends in the chorioid plexus and supplies the hippocampus and fimbria.

(4) THE ANTERIOR CEREBRAL ARTERY

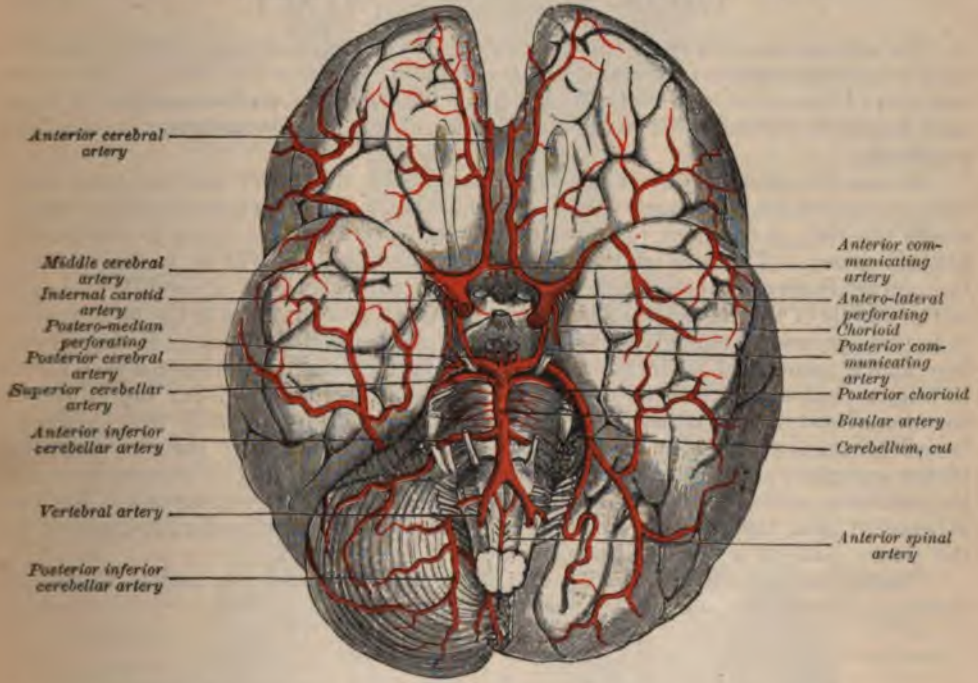
The **anterior cerebral artery** (fig. 421), one of the terminal branches int which the internal carotid divides in the lateral fissure (fissure of Sylvius), suppli a part of the cortex of the frontal and parietal lobes of the brain and a small part of the basal ganglia. It passes at first forwards and inwards across the anterior perforated space between the olfactory and optic nerves to the longitudinal fissure where it approaches its fellow of the opposite side and communicates with it by a short transverse trunk, about two lines long, known as the **anterior communicating artery** (fig. 418). Onwards from this spot it runs side by side with its fellow in the longitudinal fissure round the genu of the corpus callosum; then, turning backwards, it continues along the upper surface of that commissure, and, after giving off large branches to the frontal and parietal lobules, anastomoses with the posterior cerebral artery.

(5) THE MIDDLE CEREBRAL ARTERY

The **middle cerebral artery** (fig. 418), the larger of the two terminal divisions of the internal carotid, supplies the basal ganglion and a part of the cortex of the frontal and parietal lobes. It passes obliquely upwards and outwards into the fissure of Sylvius, and opposite the insula divides into its hemispheral or cortical branches.

FIG. 418.—THE ARTERIES OF THE BRAIN.

(The cerebellum has been cut away on the left side to show the posterior part of the cerebrum. From a preparation in the Museum of St. Bartholomew's Hospital.)


Anterior cerebral artery
Middle cerebral artery
Internal carotid artery
Postero-median perforating
Posterior cerebral artery
Superior cerebellar artery
Anterior inferior cerebellar artery
Vertebral artery
Posterior inferior cerebellar artery
Anterior communicating artery
Antero-lateral perforating
Chorioid
Posterior communicating artery
Posterior chorioid
Basilar artery
Cerebellum, cut
Anterior spinal artery

THE CIRCLE OF WILLIS

The four arteries which supply the brain, namely, the two internal carotid arteries and the two vertebrals, form a remarkable anastomosis at the base of the brain known as the circle of Willis. The two vertebrals first unite to form the basilar artery. This so-called circle, which has really the form of a heptagon, is formed, **in front,** by the anterior communicating artery uniting the anterior cerebral arteries of opposite sides; **laterally,** by the trunk of the internal carotid and the posterior communicating arteries stretching between it and the posterior cerebral; **behind,** by the two posterior cerebrals diverging from the bifurcation of the basilar artery (page 547). This free anastomosis between the two internal carotid and the two ertebral arteries serves to equalise the flow of blood to the various portions of the brain; and, should one or more of the arteries entering into the formation of the circle be temporarily or permanently obstructed, it ensures a flow of blood to the otherwise deprived part through some of the collateral arteries. Thus, if one carotid or one vertebral is obstructed, the parts supplied by that vessel receive their blood through the circle from the remaining pervious vessels. Indeed, one vertebral artery alone has been found equal to the task of carrying sufficient blood for the supply of the brain after ligature of both the carotids and the other vertebral artery. Further, the circle of Willis is the only medium of communication between the ganglionic or central and the hemispherical or cortical branches of the cerebral arteries, and between the various ganglionic branches themselves. The ganglionic and the cortical branches form separate and distinct systems, and do not anastomose with each other; and the ganglionic, moreover, are so-called end-vessels, and do not anastomose with the neighbouring ganglionic branches. The three cerebral arteries, anterior, middle and posterior, may be regarded as branches of the circle of Willis. (For details concerning the distribution of the cerebral arteries see p. 547.)

THE SUBCLAVIAN ARTERY

The **subclavian artery** on the right side arises at the bifurcation of the innominate behind the right sterno-clavicular articulation. On the left side it arises from the arch of the aorta, and as far as the inner border of the scalenus anticus is situated deeply in the chest. The first portion of the left subclavian artery is described separately.

Beyond the inner border of the scalenus anterior the artery has the same relations on both sides. It courses from this point beneath the clavicle in a slight curve across the root of the neck to the outer border of the first rib, there to end in the axillary artery. Thus the course of the artery in the neck will be indicated by a line drawn from the sterno-clavicular joint in a curve with its convexity upwards to the middle of the clavicle. The height to which the artery rises in the neck varies. It is perhaps most commonly about 1·2 cm. (½ in.) above the clavicle. If the curved line above mentioned is drawn to represent part of the circumference of a circle having its centre at a point on the lower margin of the clavicle 3·7 cm. (1½ in.) from the sternal end of that bone, the line of the artery will be sufficiently well indicated for all practical purposes. In its course the artery arches over the dome of the pleura and gains the groove on the upper surface of the first rib by passing between the scalenus anterior and medius muscles. The artery is accompanied by the subclavian vein, the latter vessel lying in front of the scalenus anterior, anterior to the artery, and on a slightly lower plane.

The subclavian artery is divided into three portions—as it lies medial to, posterior to, or lateral to, the scalenus anterior muscle.

THE FIRST OR THORACIC PORTION OF THE LEFT SUBCLAVIAN ARTERY

The **left subclavian artery** (figs. 399 and 419) arises from the termination of the transverse portion of the arch of the aorta. The first part of the left subclavian is consequently longer than the first part of the right, which arises at the bifurcation of the innominate opposite the right sterno-clavicular joint. The artery at its origin is situated deeply in the thorax, and as it arises from the aorta is on a plane posterior to and a little to the left of the thoracic portion of the left common carotid. It first ascends almost vertically out of the chest, and at the root of the neck curves outwards over the apex of the left pleura and lung to the interval between the anterior and middle scalene muscles. Beyond the inner border of the scalenus anterior—that is, in the second and third portions of its course—its relations are similar to those of the right subclavian artery.

Relations.—**In front** it is covered by the left pleura and lung, whilst more superficial are the sterno-thyreoid, sterno-hyoid, and sterno-mastoid muscles. It meningeal (sometimes). All these vessels pass through bony or cartilaginous canals.

(B) **From the second part**:—(1) The masseteric; (2) the posterior deep temporal; (3) the pterygoid; (4) the buccal; and (5) the anterior deep temporal. All these branches supply muscles.

(C) **From the third part**:—(1) The posterior superior alveolar (dental); (2) the infra-orbital; (3) the descending palatine; (4) the Vidian; and (5) the naso- or spheno-palatine. All these branches pass through bony canals.

BRANCHES OF THE FIRST PART OF THE INTERNAL MAXILLARY ARTERY

(1) The **deep auricular** (fig. 413) passes upwards in the substance of the parotid gland behind the capsule of the temporo-maxillary joint, and, perforating the bony or cartilaginous wall of the external auditory meatus, supplies the skin of that passage and the membrana tympani. It at times gives a branch to the joint as it passes behind the temporo-maxillary articular capsule.

(2) The **anterior tympanic branch** is a long slender vessel, which runs upwards behind the condyle of the jaw to the petro-tympanic (Glaserian) fissure, through which it passes to the interior of the tympanum. Here it supplies the lining membrane of that cavity and the levator tympani muscle, and anastomoses with the other tympanic arteries, forming with the tympanic branch of the stylo-mastoid artery a vascular circle around the membrana tympani. This circle is more distinct in the fœtus than in the adult.

(3) The **middle meningeal** is the largest branch of the internal maxillary artery. It comes off from that vessel as it lies between the spheno-mandibular ligament and the ramus of the jaw, and under cover of the external pterygoid passes directly upwards to the foramen spinosum, through which it enters the interior of the cranium. In this part of its course it is crossed by the chorda tympani nerve; and just before it enters the foramen is embraced by the two heads of origin of the auriculo-temporal nerve (fig. 413).

The trunk of the mandibular division of the fifth nerve, as the latter emerges through the foramen ovale, lies in front of the artery. As the artery passes upwards it is surrounded by filaments of the sympathetic nerve, and is accompanied by two veins which open into the internal maxillary vein. On entering the skull it ramifies between the bone and dura mater, supplying both structures. It at first ascends for a short distance in a groove on the greater wing of the sphenoid, and then divides into two branches, an anterior and a posterior.

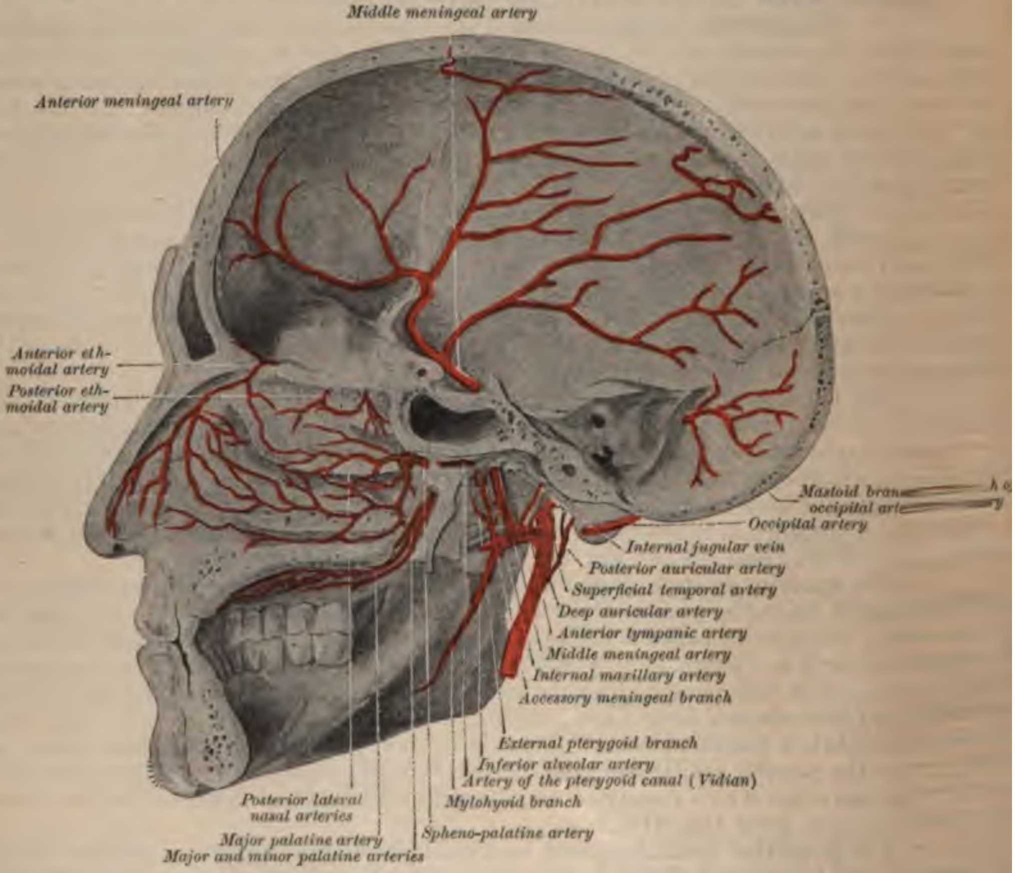
The **anterior branch** passes upwards, in the groove on the greater wing of the sphenoid, on to the parietal bone at its anterior and inferior angle; at this spot the groove becomes deepened and often bridged over by a thin plate of bone, being converted for 6 to 12 mm. (¼ to ½ in.) or more into a distinct canal. The situation of the artery is here indicated on the exterior of the skull by a spot 3·7 cm. (1½ in.) behind, and about 2·5 cm. (1 in.) above, the external angle of the orbit. The anterior branch is continued along the anterior border of the parietal bone nearly as far as the superior sagittal sinus, and gives off in its course, but especially posteriorly, large branches which ramify in an upward and backward direction in grooves on the parietal bone (fig. 414).

The **posterior branch** passes backwards over the squamous portion of the temporal bone; and thence on to the parietal bone, behind the anterior branch. This branch and its collaterals extend upwards as far as the sagittal sinus, and backwards as far as the transverse (lateral) sinus.

In addition to its terminal anterior, and terminal posterior branches, the middle meningeal gives off:—(*a*) **Gasserian branches** to the Gasserian ganglion and Meckel's space. (*b*) A **petrosal branch,** which enters the hiatus of the facial canal in company with the large superficial petrosal nerve and anastomoses with the terminal branch of the stylo-mastoid artery. (*c*) A **tympanic branch,** which enters the canal for the tensor tympani, and supplies that muscle. (*d*) An **orbital** or **lachrymal branch,** which enters the orbit at the outermost part of the superior orbital (sphenoidal) fissure, or sometimes through a minute foramen, just external to that fissure, and anastomoses with the lachrymal branch of the ophthalmic. (*e*) **Anastomotic** or **perforating branches** which pierce the greater wing of the sphenoid bone, and anastomose with the deep temporal arteries.

(4) The **inferior alveolar (dental) artery** (fig. 413), arising from the internal maxillary as it lies between the spheno-mandibular ligament and neck of the jaw, courses downwards to the mandibular foramen, which it enters in company with, and a little behind and external to, the inferior alveolar nerve. It then passes along the canal in the interior of the bone, giving off branches to the molar, bicuspid, and canine teeth. On reaching the mental foramen it divides into two branches, the incisive and the mental. The **incisive** continues its course in the bone, supplies branches to the incisor teeth, and anastomoses with the artery of the opposite side. The **mental** passes through the mental foramen in company with the mental branch of the inferior alveolar (dental) nerve, and emerges on the chin under cover of the quadratus labii inferioris. It anastomoses above with the inferior labial (coronary), and below with the submental, and also with the inferior labial. Near its origin the artery gives off (*a*) a **lingual** or **gustatory branch**, which accompanies and supplies the lingual nerve, and ends in the mucous membrane of the mouth; and, just before it enters the mandibular (dental) foramen in the lower jaw, (*b*) a **mylo-hyoidean branch,** which accompanies the nerve of that name along the groove in the lower jaw, and, after supplying the mylo-hyoid muscle, anastomoses with the sublingual and submental arteries.

FIG. 414.—THE MIDDLE MENINGEAL ARTERY WITHIN THE SKULL. (After Spalteholz.)


Middle meningeal artery
Anterior meningeal artery
Anterior ethmoidal artery
Posterior ethmoidal artery
Mastoid branch of occipital artery
Occipital artery
Internal jugular vein
Posterior auricular artery
Superficial temporal artery
Deep auricular artery
Anterior tympanic artery
Middle meningeal artery
Internal maxillary artery
Accessory meningeal branch
External pterygoid branch
Inferior alveolar artery
Artery of the pterygoid canal (Vidian)
Mylohyoid branch
Spheno-palatine artery
Posterior lateral nasal arteries
Major palatine artery
Major and minor palatine arteries

(5) The **accessory (small) meningeal** arises either from the internal maxillary a little in front of the middle meningeal, or as a branch of the latter vessel. It passes upwards along the course of the mandibular division of the fifth nerve, and, entering the skull through the foramen ovale, is distributed to the Gasserian ganglion, and to the walls of the cavernous sinus and the dura mater in the neighbourhood.

BRANCHES OF THE SECOND PART OF THE INTERNAL MAXILLARY ARTERY

The branches of the second portion of the internal maxillary all supply muscles. They are:—(1) The masseteric; (2) the posterior deep temporal; (3) the pterygoid; (4) the buccal; and (5) the anterior deep temporal.

(1) The **masseteric branch** comes off from the internal maxillary as the latter is passing from between the neck of the jaw and the spheno-mandibular ligament. It is directed outwards along with the masseteric nerve, and, passing through the mandibular (sigmoid) notch in the lower jaw, supplies the masseter muscle. Some filaments perforate the muscle and anastomose with the transverse facial and with the masseteric branches of the external maxillary (facial).

(2) The **posterior deep temporal** arises, as a rule, from the internal maxillary in common with the masseteric for a little beyond that branch. It passes upwards beneath the temporal muscle in a slight groove on the anterior margin of the squamous portion of the temporal bone, supplying the temporal muscle, the pericranium, and the external layer of the bone. It anastomoses with the anterior deep temporal and the other temporal arteries.

(3) The **pterygoid branches** are short trunks which pass into and supply the internal and external pterygoid muscles.

(4) The **buccal branch** (fig. 413) courses forwards and downwards with the buccal nerve to the buccinator muscle, lying in close contact with the inner side and anterior margin of the tendon of the temporal muscle and coronoid process of the lower jaw. It supplies the buccinator muscle and mucous membrane of the mouth, and anastomoses with the external maxillary (facial), transverse facial, and infraorbital arteries.

(5) The **anterior deep temporal branch** ascends beneath the temporal muscle in a slight groove on the greater wing of the sphenoid bone. It supplies the muscle, pericranium, and subjacent bone, and gives off small branches which pass through minute foramina in the zygomatic (malar) bone. Some of these last branches enter the orbit and anastomose with the lachrymal artery; others emerge on the face and anastomose with the transverse facial artery.

BRANCHES OF THE THIRD PART OF THE INTERNAL MAXILLARY ARTERY

The branches of the third part of the internal maxillary artery, like those of the first part, all pass through bony canals. They are the following:—(1) The posterior superior alveolar (dental); (2) the infraorbital; (3) the descending palatine; (4) the artery of the pterygoid canal (Vidian); (5) the pterygo-palatine; and (6) the spheno-palatine.

(1) The **posterior superior alveolar (dental) branch** arises from the internal maxillary as the latter is passing into the pterygo-palatine (spheno-maxillary) fossa, and descends in a tortuous manner in a groove on the back of the body of the maxilla. It gives off branches to the maxillary sinus, to the molar and bicuspid teeth, the gums, and to the buccinator muscle.

(2) The **infraorbital branch** arises from the internal maxillary, generally as a common trunk with the posterior alveolar (dental). It passes forwards and a little upwards through the pterygo-palatine (spheno-maxillary) fossa; then forwards in company with the maxillary division of the fifth nerve, first along the groove, and then through the canal in the orbital plate of the maxilla; and finally, emerging on the face at the infraorbital foramen, under cover of the quadratus labii superioris, is distributed to the structures forming the upper lip, the lower eyelid, the lachrymal sac, and the side of the nose. It anastomoses with the superior labial (coronary) and angular branches of the external maxillary (facial), with the nasal and lachrymal branches of the ophthalmic, and with the transverse facial. It gives off small branches supplying the fat of the orbit and the inferior rectus and inferior oblique muscles. The **anterior superior alveolar (dental) branch** passes downwards through a groove in the anterior wall of the maxilla, together with the anterior alveolar (dental) branch of the infraorbital nerve, and supplies branches to the incisor and canine teeth and the mucous membrane of the maxillary sinus. It has also **nasal branches** which pass through the foramina in the nasal process of the maxilla.

(3) The **descending palatine branch** descends in the posterior palatine canal

cases, in consequence of the right fourth arch which forms the first portion of the subclavian being obliterated, follows a direct course to the larynx instead of winding recurrently round the subclavian artery.

(B) The right subclavian may arise higher or lower in the neck than usual, according as the innominate divides above or below the normal situation.

(C) It may perforate the scalenus anterior or pass in front of that muscle.

(D) It may ascend as high as 3.7 cm. (1½ in.) above the clavicle, or remain below the level of that bone.

(E) The third part of the artery may be covered by the trapezius or sterno-mastoid, or by a clavicular origin of the omo-hyoid.

(F) The subclavian vein may accompany the artery behind the scalenus anterior.

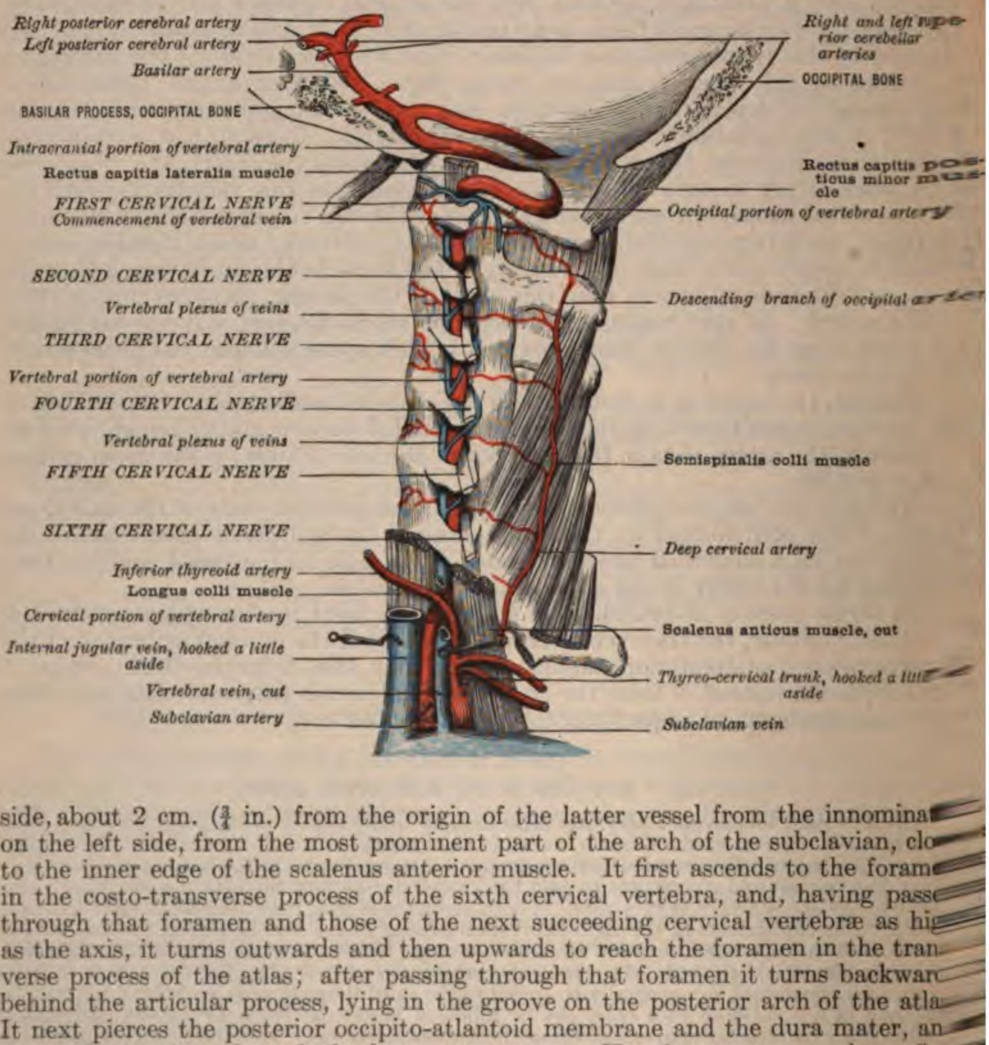
Branches of the First Part of the Subclavian Artery

THE VERTEBRAL ARTERY

The **vertebral artery,** the first, largest, and most constant branch, arises from the upper and posterior part of the first portion of the subclavian, on the right side, about 2 cm. (¾ in.) from the origin of the latter vessel from the innominat on the left side, from the most prominent part of the arch of the subclavian, clo to the inner edge of the scalenus anterior muscle. It first ascends to the foram in the costo-transverse process of the sixth cervical vertebra, and, having passe through that foramen and those of the next succeeding cervical vertebræ as hi as the axis, it turns outwards and then upwards to reach the foramen in the tran verse process of the atlas; after passing through that foramen it turns backwar behind the articular process, lying in the groove on the posterior arch of the atla It next pierces the posterior occipito-atlantoid membrane and the dura mater, an enters the cranium through the foramen magnum. Here it passes upwards, at fir lying by the side of the medulla, then in front of that structure, and terminates a

Fig. 420.—Scheme of the Left Vertebral Artery. (Walsham.)

The internal jugular and vertebral veins are hooked aside to expose the artery.


Right posterior cerebral artery
Left posterior cerebral artery
Basilar artery
BASILAR PROCESS, OCCIPITAL BONE
Intracranial portion of vertebral artery
Rectus capitis lateralis muscle
FIRST CERVICAL NERVE
Commencement of vertebral vein
SECOND CERVICAL NERVE
Vertebral plexus of veins
THIRD CERVICAL NERVE
Vertebral portion of vertebral artery
FOURTH CERVICAL NERVE
Vertebral plexus of veins
FIFTH CERVICAL NERVE
SIXTH CERVICAL NERVE
Inferior thyreoid artery
Longus colli muscle
Cervical portion of vertebral artery
Internal jugular vein, hooked a little aside
Vertebral vein, cut
Subclavian artery
Right and left superior cerebellar arteries
OCCIPITAL BONE
Rectus capitis posticus minor muscle
Occipital portion of vertebral artery
Descending branch of occipital artery
Semispinalis colli muscle
Deep cervical artery
Scalenus anticus muscle, cut
Thyreo-cervical trunk, hooked a little aside
Subclavian vein

the lower portion of the pons by anastomosing with the vertebral of the opposite side to form the basilar.

The vertebral artery may be divided for purposes of description into four parts: the **first,** or **cervical,** extending from its origin to the transverse process of the sixth cervical vertebra; the **second,** or **vertebral,** situated in the costo-transverse foramina; the **third,** or **occipital,** contained in the suboccipital triangle; and the **fourth,** or **intracranial,** within the cranium.

The first or cervical portion.—The artery here lies between the scalenus anterior and longus colli muscles. **In front** it is covered by the vertebral and internal jugular veins, and is crossed by the inferior thyreoid artery, and on the left side, in addition, by the thoracic duct, which runs over it from within outwards. **Behind,** the artery lies on the transverse process of the seventh cervical vertebra and the sympathetic nerve. To its **inner side** is the longus colli. To its **outer side** is the scalenus anterior. It gives off as a rule no branch in this part of its course. Occasionally, however, a small branch passes into the foramen of the transverse process of the seventh cervical vertebra.

The second or vertebral portion.—As the artery passes through the costo-transverse foramina, it is surrounded by a plexus of veins and by branches of the sympathetic nerve. The cervical nerves lie behind it. Between the transverse processes it is in contact with the intertransverse muscles.

The third or occipital portion.—The artery here lies in the suboccipital triangle, bounded by the superior oblique, inferior oblique, and rectus capitis posterior major muscles. As it winds round the groove on the atlas, it has the rectus capitis lateralis, the articular process, and the occipito-atlantoid ligament **in front** of it; the superior oblique, the rectus capitis posterior major, and the semispinalis capitis (complexus) **behind** it. Separating it from the arch of the atlas, is the first cervical or suboccipital nerve.

The **fourth** or **intracranial portion** extends from the aperture in the dura mater to the lower border of the pons, where it unites with its fellow to form the basilar artery. It here winds round from the side to the front of the medulla, lying in the vertebral groove on the basilar process of the occipital bone. In this course it passes beneath the first process of the ligamentum denticulatum, and between the hypoglossal nerve in front, and the anterior roots of the suboccipital nerve behind.

Chief Variations of the Vertebral Artery

(A) The right vertebral artery may arise from the first part of the subclavian, either nearer to the innominate, or nearer to the anterior scalene muscle than normal.

(B) It may come off from the arch of the aorta directly.—(See VARIATIONS IN THE CHIEF BRANCHES OF THE ARCH OF THE AORTA.)

(C) It may arise from the right common carotid when the right subclavian is given off from the aorta beyond the left subclavian.

(D) It may pass behind the œsophagus.

(E) The left vertebral artery may also arise from the arch of the aorta direct, or from the left common carotid. (See VARIATIONS IN THE CHIEF BRANCHES OF THE AORTA.)

(F) Either vertebral may enter the foramen in the seventh cervical vertebra, or in that of the fifth, fourth, third, or second. When entering one of the higher vertebral foramina, it may lie behind the common carotid, and cause some embarrassment in the ligature of the latter vessel.

(G) Either vertebral may give off the inferior thyreoid, superior intercostal, deep cervical, or occipital artery.

(H) One or other artery may be much increased or diminished in size.

BRANCHES OF THE VERTEBRAL ARTERY

A. **Cervical portion.**—No branch.

B. **Vertebral portion.**—1. Spinal; 2. muscular.

C. **Occipital portion.**—1. Muscular; 2. anastomotic.

D. **Cranial portion.**—1. Posterior meningeal; 2. posterior spinal; 3. anterior spinal; 4. posterior inferior cerebellar.

BRANCHES OF THE SECOND OR VERTEBRAL PORTION

1. The **spinal branches** run through the intervertebral foramina into the vertebral canal, and there divide into two branches: one of which ramifies on the backs of the bodies of the cervical vertebræ; while the other runs along the spinal nerves,

supplies the cord and its membranes, and anastomoses with the arteries above and below. 2. The **muscular branches** supply the deep muscles of the neck, and anastomose with the ascending cervical, occipital, and deep cervical arteries.

Branches of the Third or Occipital Portion

In the third portion are given off branches which supply the muscles forming the suboccipital triangle and anastomose with branches of the occipital artery.

Branches of the Fourth or Cranial Portion

1. The **posterior meningeal** is a small branch given off as the vertebral artery pierces the dura mater to enter the cranium. It supplies the bone and dura mater of the posterior fossa of the skull, and anastomoses with the posterior meningeal branches derived from the occipital and ascending pharyngeal arteries. It gives branches to the falx cerebelli.

2. The **posterior spinal artery** runs downwards obliquely along the side of the medulla to the back of the cord, down which it passes behind the roots of the spinal nerves, being reinforced by lateral branches running inwards along these nerves, in the neck from the vertebral, in the thoracic region from the intercostals, and in the lumbar region from the lumbar arteries. It can be traced as low as the end of the spinal cord.

3. The **anterior spinal artery** comes off from the vertebral a little below its termination in the basilar artery. Descending obliquely inwards in front of the medulla, it unites on a level with the foramen magnum with its fellow of the opposite side. The single vessel thus formed runs downwards in front of the spinal cord beneath the pia mater as far as the termination of the cord, being reinforced by the lateral spinal branches the whole way down. The spinal arteries are described in detail with the anatomy of the spinal cord.

4. The **posterior inferior cerebellar** (fig. 418)—the largest branch of the vertebral—arises from that vessel just before it joins its fellow to form the basilar artery. At times it may come off from the basilar itself. It runs, at first outwards across the restiform body between the origin of the vagus and hypoglossal nerves, and, descending towards the vallecula, there divides into two branches, an internal and external. (*a*) The *internal* or *inferior vermian branch* runs backwards between the vermis and the lateral hemisphere of the cerebellum. It supplies the vermis, and anastomoses with the artery of the opposite side, and with the superior vermian branch of the superior cerebellar. (*b*) The *external* or *hemispheral branch* runs outwards, and, ramifying over the under surface of the cerebellar hemisphere, supplies its cortex and anastomoses along its outer margin with the superior cerebellar arteries.

From the undivided trunk of the posterior inferior cerebellar artery branches are given to the medulla oblongata, supplying the chorioidal plexus and the fourth ventricle.

THE BASILAR ARTERY

The **basilar artery** is formed by the confluence of the right and left vertebral arteries, which meet at an acute angle at the lower border of the pons. It runs forwards and upwards in a slight groove in the middle line of the pons, and divides at the upper border of that structure at the level of the tentorial notch into the two posterior cerebral arteries, which take part in the formation of the circle of Willis.

Branches of the Basilar Artery

The **branches of the basilar artery** are:—1. Pontal; 2. internal auditory; 3. anterior inferior cerebellar; 4. superior cerebellar; 5. posterior cerebral.

1. The **pontal** or **transverse arteries** are numerous small vessels which come off at right angles on either side of the basilar artery, and, passing outwards over the pons, supply that structure and adjacent parts of the brain.

2. The **internal auditory artery,** a long slender vessel, accompanies the auditory nerve into the internal auditory meatus (fig. 478). It here lies between the

facial and auditory nerves, and at the bottom of the meatus passes into the internal ear, and anastomoses with the other auditory arteries. (See INTERNAL EAR.)

3. The **anterior inferior cerebellar** arises from the basilar soon after its origin, passes outwards and backwards across the pons, and then over the crus cerebelli to the front part of the under surface of the cerebellum. It anastomoses with the posterior inferior cerebellar artery (fig. 418).

4. The **superior cerebellar** comes off from the basilar immediately behind its bifurcation into the posterior cerebral arteries. It courses outwards and backwards over the pons, in a curve roughly corresponding to that of the posterior cerebral artery, from which it is separated by the third cranial nerve; but, soon sinking into the groove between the pons and the crus cerebri, it curves round the latter structure on to the upper surface of the cerebellum, lying nearly parallel to the fourth nerve. Here it divides into two branches, an internal and external. (*a*) The *internal* or *superior vermian branch* courses backwards along the superior vermis, anastomosing with its fellow of the opposite side, and, at the posterior notch of the cerebellum, with the inferior vermian branch of the posterior inferior cerebellar artery. (*b*) The *external* or *hemispheral branch* runs outwards to the circumference of the cerebellum, anastomosing with the external branch of the inferior posterior cerebellar artery.

Branches are given off from the main trunk of the superior cerebellar artery, or from its internal branch to the anterior velum (valve of Vieussens), the optic lobes, the pineal body, and the chorioid plexus.

5. The **posterior cerebral arteries** are the two terminal branches into which the basilar bifurcates at the upper border of the pons, immediately behind the posterior perforated space. Each artery runs at first outwards and a little forwards across the crus cerebri immediately in front of the third nerve, which separates it from the superior cerebellar artery. After receiving the posterior communicating artery, which runs backwards from the internal carotid, the posterior cerebral turns backwards on to the under surface of the cerebral hemisphere, where it breaks up into branches for the supply of the temporal and occipital lobes.

The **branches of the posterior cerebral artery** are described below in connection with those of the other cerebral arteries.

DISTRIBUTION OF THE CEREBRAL ARTERIES

Since the brain receives its blood supply from two distinct sources, namely, from the internal carotids and from the subclavians, it is convenient to consider together the distribution of the various cerebral branches derived from these stems.

The **anterior cerebral artery** has but a limited **central** distribution. It gives off a few inconstant branches which enter the anterior perforated space and supply the anterior end of the caudate nucleus. One or two of these run to the corpus callosum and septum pellucidum. The **anterior communicating** branch is a transverse trunk which connects the two arteries and thereby completes the circle of Willis in front. It lies in front of the optic chiasm, and varies considerably in length and size. It may give off some of the branches to the anterior perforated space. The **cortical branches** supply the gyrus rectus, the olfactory lobe and a part of the orbital gyri on the ventral surface. On the mesial surface branches supply the cortex as far back as the parieto-occipital fissure. These branches are given off as the artery curves around the corpus callosum and some of them curve over on to the lateral surface and supply the superior and middle temporal convolutions. Branches from the anterior cerebral artery also supply the corpus callosum.

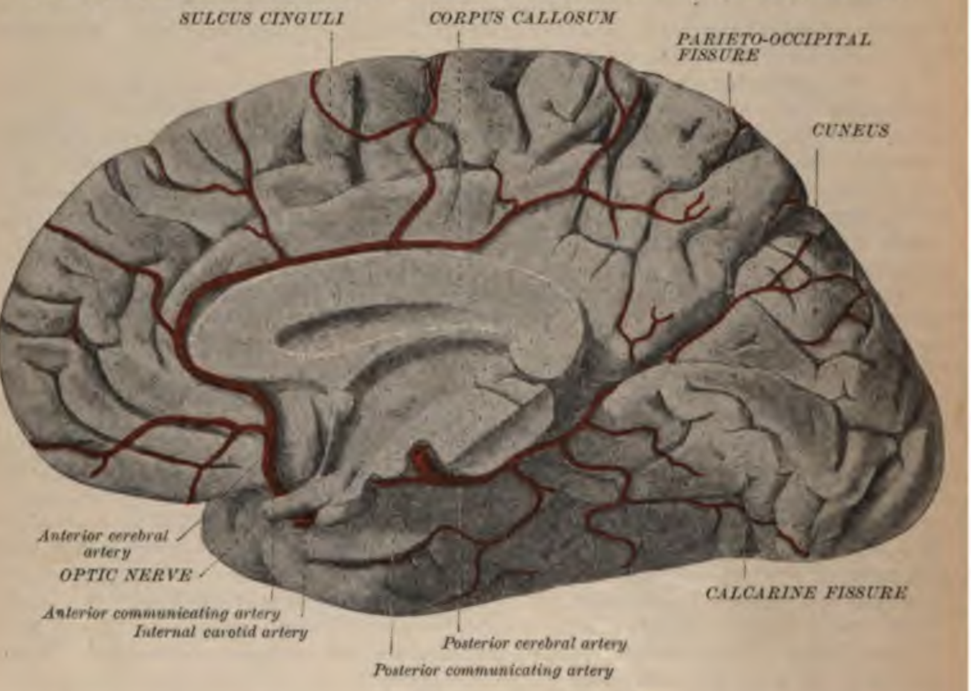
The **middle cerebral artery** gives off most of the branches to the basal ganglia and supplies the greater part of the lateral surface of the brain. It runs through the lateral fissure (fissure of Sylvius).

The **central branches** are:—(i) The **caudate,** two or three small branches, which arise from the inner aspect of the artery and pass through the inner part of the floor of the lateral fissure (fissure of Sylvius) to the head of the caudate nucleus. (ii) The **antero-lateral** are numerous small arteries which pass through the anterior perforated space and supply the caudate nucleus (except its head), the internal capsule, and part of the optic thalamus. (iii) The **lenticulo-striate,** a larger branch of the anterolateral set, passes through a separate hole in the outer part of the anterior perforated space, runs upward between the lenticular nucleus, which it supplies, and the external capsule, perforates the internal capsule, and terminates in the caudate nucleus. It has been so frequently found ruptured in apoplexy that it is called by Charcot the 'artery of cerebral hæmorrhages.' (iv) Sometimes a more or less distinct branch, called **lenticulo-optic,** is distributed to the outer and hinder portion of the lenticular nucleus and the external portion of the optic thalamus.

The **cortical branches** come off opposite the insula. They supply the insula, the inferior frontal gyri, the central gyri anterior and posterior, the parietal lobules superior and inferior, the supra-marginal, angular, and superior temporal gyri.

The **posterior cerebral** give off both central and cortical branches. The **central branches** are the postero-median, posterior chorioid, and the postero-lateral. The **postero-median** enter the posterior perforated space and supply the inner part of the optic thalamus, and the walls of the third ventricle; the **posterior chorioid** pass through the transverse fissure to the tela chorioidea (velum interpositum) and chorioid plexus; the **postero-lateral** run to the posterior part of the optic thalamus and give branches to the cerebral peduncles and the corpora quadrigemina.

FIG. 421.—THE ARTERIES OF THE MESIAL SURFACE OF THE BRAIN. (After Spalteholz.)



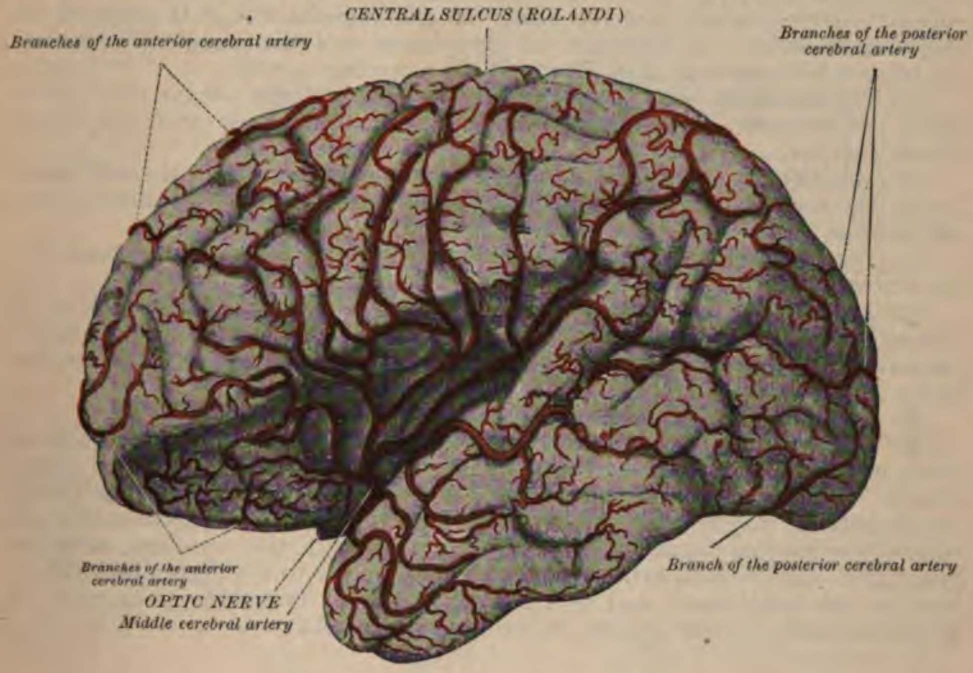
The **cortical branches** supply the entire occipital lobe and all of the temporal lobe except the superior temporal gyrus.

In regard to the cerebral arteries in general it may be said that there is no anastomosis between the cortical and central branches, the two forming distinct and separate systems. The cortical may or may not anastomose with each other, but the communication between the neighbouring cortical branches is seldom sufficient to maintain the nutrition of an area when the vessel that normally supplies it is obstructed. The central branches are so-called end-vessels and do not anastomose with each other. Hence obstruction of the middle cerebral artery leads to softening of the area supplied by its central branches, but not always to softening of the region supplied by its cortical branches. Indeed, the cortical region may escape completely, although the central area is irreparably disorganised. The gross anastomosis of the posterior cerebral with the anterior cerebral arteries through the circle of Willis has already been described. To sum up the distribution of the cerebral arteries, the branches of each are divided into the central, or ganglionic, and the cortical or hemispheral. The central branches arise at the commencement of the cerebral arteries about the circle of Willis, whilst the cortical are derived chiefly from the termination of these vessels.

(A) The **central branches** are divided into six sets—two median and four lateral. 1. The **two median** are—(1) The **antero-median,** which arise from the anterior cerebral and the anterior communicating, and supply the fore end of the caudate nucleus, and (2) the **postero-median,** which arise from the posterior cerebral and supply the inner part of the optic thalamus and neighbouring wall of the third ventricle. 2. The **four lateral,** two on each side, are also divided into antero-lateral and postero-lateral. (1) The **antero-lateral** arise from the middle cerebral, and, passing through the anterior perforated substance, supply the lenticular nucleus, the posterior part of the caudate nucleus, the internal and external capsules, and the outer part of the optic thalamus. (2) The **postero-lateral** arise from the posterior cerebral, and supply the hinder part of the optic thalamus, the crus, and the optic lobes or corpora quadrigemina.

(B) The **cortical branches** ramify in the pia mater, giving off branches to the cortical substance, some of which extend through it to the underlying white substance.

FIG. 422.—THE ARTERIES OF THE LATERAL SURFACE OF THE BRAIN. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


CENTRAL SULCUS (ROLANDI)
Branches of the anterior cerebral artery
Branches of the posterior cerebral artery
Branches of the anterior cerebral artery
OPTIC NERVE
Middle cerebral artery
Branch of the posterior cerebral artery

It will be seen that the middle cerebral supplies the motor region, both central and cortical, except a part of the leg centre. It also supplies the region of the cortex that subserves cutaneous sensibility, the cortical auditory centre, and, in part, the higher visual centre. It likewise supplies all the cortical regions concerned in speech processes in the left hemisphere. The anterior cerebral supplies only a small part of the motor region, namely, the part of the leg centre that occupies the paracentral lobule and the highest part of the anterior central (ascending frontal) convolution. The posterior cerebral supplies the visual path from the middle of the tract backwards, and the half vision centre in the occipital lobe. It supplies also the corpora quadrigemina and the sensory part of the internal capsule.

The branches which supply the cerebellum and brain stem are given in connection with the vertebrals on page 546.

THE THYREOCERVICAL TRUNK (THYREOID AXIS)

The **thyreocervical trunk** or **thyreoid axis** arises from the upper and front part of the subclavian artery, usually opposite the internal mammary, and a little internal to the inner border of the scalenus anterior. It is a short thick trunk, and divides almost immediately into three radiating branches—namely, the **inferior thyreoid,** the **transverse scapular,** and the **transverse cervical** (figs. 406, 419). This is the usual form only on the left side. See page 556. It may give off also the **ascending cervical.**

THE INFERIOR THYREOID ARTERY

The **inferior thyreoid** is the largest of the three branches into which the thyreocervical trunk (thyreoid axis) divides, and may arise in a common trunk with the transverse scapular, or as a branch of the subclavian. It ascends tortuously upwards and inwards in front of the vertebral artery, the inferior laryngeal nerve and the longus colli muscle, and behind the common carotid and the sympathetic nerve or its middle cervical ganglion, to the thyreoid body, where it anastomoses with the superior thyreoid artery and the artery of the opposite side. It gives off the following branches:—(1) Muscular; (2) œsophageal and pharyngeal; (3) tracheal; (4) inferior laryngeal; (5) glandular; and (6) ascending cervical.

(1) The **muscular branches** supply the scalenus anterior, longus colli, sterno-hyoid, sterno-thyreoid, and omo-hyoid muscles, and the inferior constrictor muscle of the pharynx.

(2) The **œsophageal and pharyngeal branches** of the inferior thyreoid artery supply the œsophagus and pharynx and anastomose with the other arteries supplying those structures.

(3) The **tracheal branches** ramify on the trachea, where they anastomose with the tracheal branches of the superior thyreoid and bronchial arteries.

(4) The **inferior laryngeal branch** passes along the trachea to the back of the cricoid cartilage in company with the inferior laryngeal nerve. It enters the larynx beneath the inferior constrictor. Its further distribution in that organ is described under LARYNX.

(5) The **glandular** branches supply the thyreoid gland.

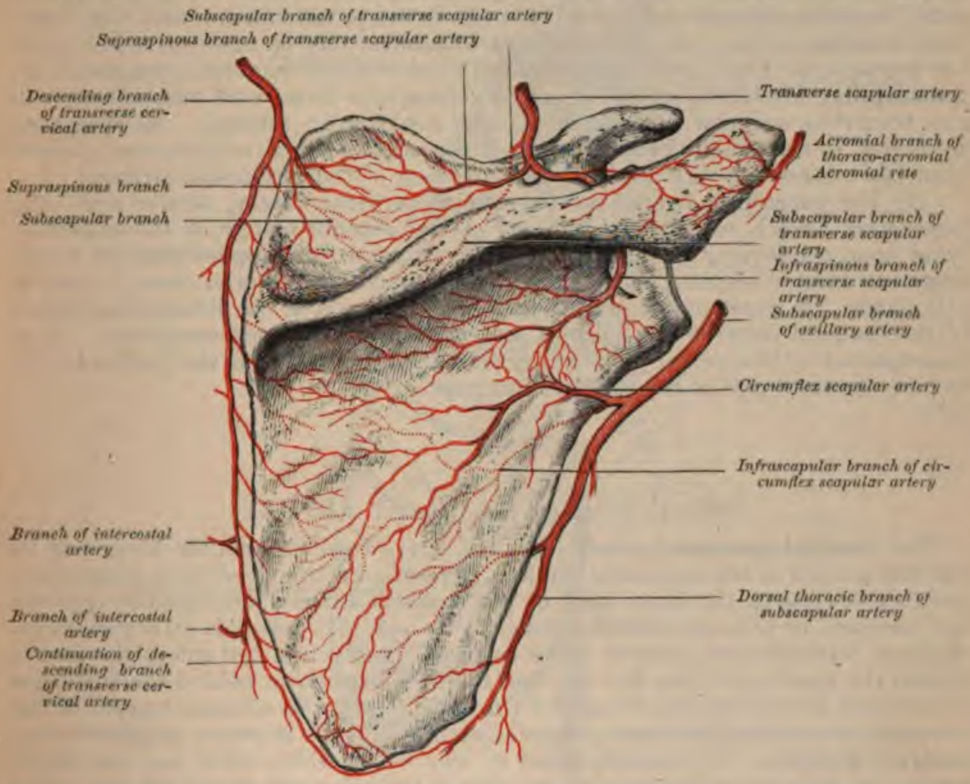
(6) The **ascending cervical** (figs. 406, 419) is given off from the thyreocervical trunk or from the inferior thyreoid as that vessel is passing beneath the carotid sheath. It ascends between the scalenus anterior and the longus capitis (rectus capitis anterior major), lying parallel and a little internal to the phrenic nerve and behind the internal jugular vein. It anastomoses with the vertebral, ascending pharyngeal, and occipital arteries, and supplies branches to the deep muscles of the neck, to the spinal canal, and to the phrenic nerve. Two veins accompany the ascending cervical artery and end in the innominate vein.

THE TRANSVERSE SCAPULAR (SUPRASCAPULAR) ARTERY

The **transverse scapular** or **suprascapular** passes more or less transversely outwards across the root of the neck, lying first beneath the sterno-mastoid, and then in the subclavian triangle behind the clavicle and subclavius muscle. At the external angle of this space it is joined by the suprascapular nerve, sinks beneath the posterior belly of the omo-hyoid, and passes over the ligament bridging the scapular notch, the nerve passing through the notch (fig. 423). It then ramifies in the supraspinous fossa of the scapula, and, winding downwards round the base of the spine over the neck of the scapula, enters the infraspinous fossa, and terminates by anastomosing with the circumflex (dorsal) scapular artery, and the descending branch of the transverse cervical (posterior scapular) artery. As it lies under cover of the sterno-mastoid muscle, it crosses the phrenic nerve and the scalenus anterior; and as it courses through the subclavian triangle, it is separated by the cervical fascia which descends from the omo-hyoid to the first rib, from the subclavian artery and brachial plexus of nerves. If this artery is seen in tying the subclavian it should not be injured, as it is one of the chief vessels by which the collateral circulation is carried on after ligature of the subclavian in the third part of its course. At the outer part of the subclavian triangle it is covered by the trapezius, and after passing over the transverse scapular ligament it pierces the supraspinous fascia and passes beneath the supra-spinatus muscle, ramifying between it and the bone. In the infraspinous fossa it lies between the infra-spinatus and the bone. The artery is accompanied by two veins.

The **branches of the transverse scapular** are:—(1) The inferior sterno-mastoid, given off to that muscle as the vessel crosses behind it; (2) the subclavicular to the subclavius muscle; (3) the nutrient, to the clavicle; (4) the suprasternal, which passes over the sternal end of the clavicle to the skin of the upper part of the chest; (5) the acromial, to the arterial rete or plexus on the acromial process, to reach which it pierces the trapezius; (6) the articular, to the acromio-clavicular joint and shoulder-joint; (7) the subscapular, given off as the artery is passing over the transverse scapular ligament, descends to the subscapular fossa between the subscapularis and the bone, and anastomoses with the infrascapular branch of the circumflex (dorsal) scapular artery, and with the subscapular and posterior scapular arteries; (8) the supraspinous branches, which ramify in the supraspinous fossa, and supply the supra-spinatus muscle and the periosteum, and the nutrient artery to the bone; (9) the infraspinous branches, which ramify in a similar way in the infraspinous fossa, giving off twigs to the infra-spinatus muscle, the periosteum, and the bone.

FIG. 423.—SCHEME OF ANASTOMOSES OF THE RIGHT SCAPULAR ARTERIES. (Walsham.)


Subscapular branch of transverse scapular artery
Supraspinous branch of transverse scapular artery
Descending branch of transverse cervical artery
Supraspinous branch
Subscapular branch
Transverse scapular artery
Acromial branch of thoraco-acromial
Acromial rete
Subscapular branch of transverse scapular artery
Infraspinous branch of transverse scapular artery
Subscapular branch of axillary artery
Circumflex scapular artery
Infrascapular branch of circumflex scapular artery
Branch of intercostal artery
Dorsal thoracic branch of subscapular artery
Branch of intercostal artery
Continuation of descending branch of transverse cervical artery

THE TRANSVERSE CERVICAL ARTERY

The **transverse cervical** or **transversa colli artery**—somewhat larger than the transverse scapular (suprascapular)—runs like the latter vessel transversely outwards across the root of the neck, but on a slightly higher plane, and a little above the clavicle. At its origin from the thyreo-cervical trunk (thyreoid axis) it lies under the sterno-mastoid; on leaving the cover of this muscle, it crosses the upper part of the subclavian triangle, lying here only beneath the platysma and cervical fascia; further outwards, it passes beneath the anterior margin of the trapezius and omo-hyoid muscle, and at the outer margin of the levator scapulæ divides into a descending (posterior scapular) and an ascending (superficial cervical) branch. In this course it crosses the phrenic nerve, the scalenus anterior, the brachial plexus, and the scalenus medius. At times it passes between the cords of the brachial plexus.

The **terminal branches of the transverse cervical artery** are:—(1) a descending; and (2) an ascending cervical. The descending branch occasionally arises from the third portion of the subclavian artery.

(1) The **descending branch** or **posterior scapular**—the apparent continuation of the transverse cervical artery—begins at the outer border of the levator scapulæ, and, continuing its course beneath this muscle to the upper and posterior angle of the scapula, turns downwards and skirts along the posterior border of the scapula, between the serratus anterior (magnus) in front and the levator scapulæ and rhomboideus minor and major behind, to the inferior angle, where it anastomoses with the subscapular artery. It gives off the following branches:—(*a*) **Supraspinous,** which ramifies between the supraspinous muscle and the trapezius, and sends branches through the muscle into the fossa, to anastomose with the transverse scapular artery. (*b*) **Infraspinous branches,** one or more of which enter the infraspinous fossa, and anastomose with the circumflex (dorsal) scapular. (*c*) **Subscapular branches,** which enter the subscapular fossa, and anastomose with the transverse scapular, infrascapular, and subscapular arteries. (*d*) **Muscular branches,** to the muscles between which it runs and to the latissimus dorsi. These branches anastomose with the posterior divisions of the intercostal arteries.

(2) The **ascending branch** or **superficial cervical artery,** smaller than the descending branch, ascends under cover of the anterior margin of the trapezius, lying upon the levator scapulæ and splenius muscles. It supplies branches to the trapezius, levator scapulæ, and splenius muscles, and the posterior chain of lymphatic glands. It anastomoses with the superficial branch of the descending branch of the occipital between the splenius and semispinalis capitis (complexus). It is accompanied by two veins. This artery may arise directly from the thyreoid axis, or from the third part of the subclavian artery.

THE INTERNAL MAMMARY ARTERY

The **internal mammary artery** (figs. 419, 424) comes off from the lower part of the first portion of the subclavian, usually opposite the thyreo-cervical trunk (thyreoid axis), close to the inner edge of the scalenus anterior, occasionally opposite the vertebral, or at a spot between these two vessels. It descends with a slight inclination forwards and inwards, under cover of the clavicle, and enters the thorax behind the cartilage of the first rib, and thence passes down behind the cartilages of the next succeeding ribs, about 1·2 cm. (½ in.) from the external margin of the sternum, to the sixth interspace, where it divides into the **superior epigastric** and **musculo-phrenic.** It is accompanied by two veins, which unite into one trunk behind the first intercostal muscle, and pass to the inner side of the artery into the corresponding vena innominata; occasionally on the right side into the vena cava superior direct. The artery may be divided into two portions, the cervical and the thoracic.

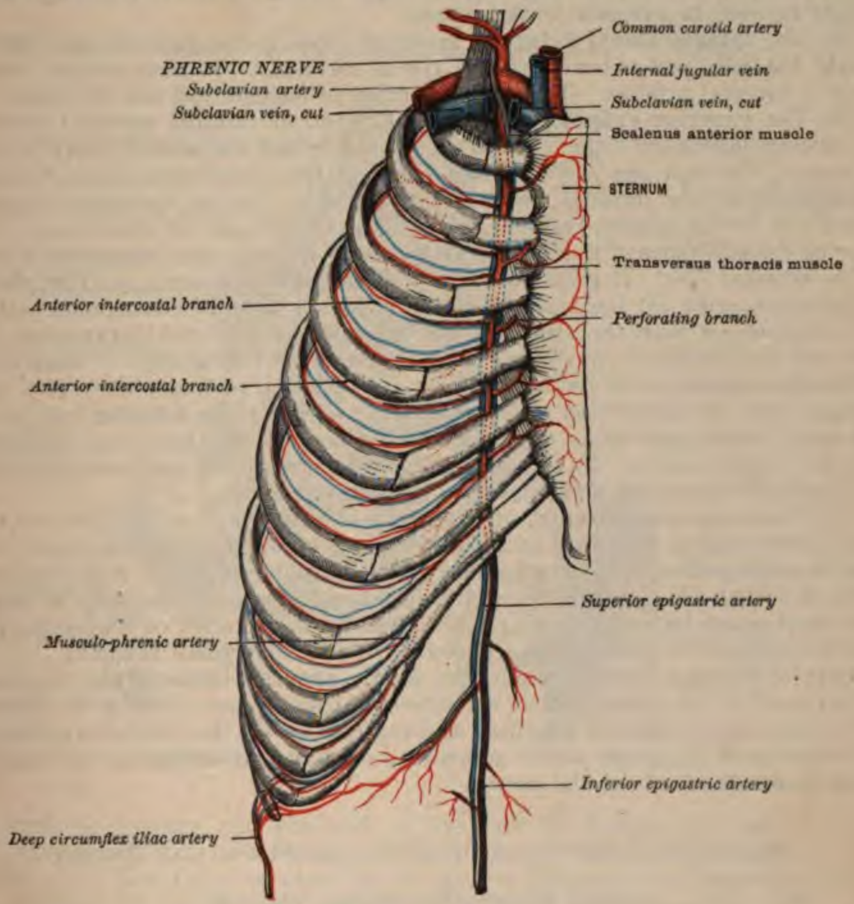
The **cervical portion** is covered by the sterno-mastoid muscle, subclavian vein, and internal jugular vein, and is crossed obliquely, from without inwards, by the phrenic nerve. It rests upon the pleura and courses around the upper part of the innominate vein. There is no branch from this part of the artery.

The **thoracic portion** lies behind the cartilages of the six upper ribs, and *in* the interspace between the ribs has in front of it the pectoralis major and the internal intercostal muscles and external intercostal ligaments. Behind, it is in contact above with the pleura, but it is separated from it lower down by slip of the transversus thoracis (triangularis sterni). On the left side, the artery betwe the fourth and sixth ribs may be said to be in the anterior mediastinum, the ple here forming a notch for the heart. In the first, second, and third spaces the arte if wounded, can be easily tied; but in the fourth space the operation is atten with more difficulty. The remaining spaces are so narrow that a portion of the cartilage would have to be removed to expose the vessel.

The **branches of the internal mammary artery** are:—(1) The pericardiophrenic; (2) the anterior mediastinal and thymic; (3) the bronchial; (4) the pericardiac; (5) the sternal; (6) the anterior intercostals; (7) the perforating; (8) the lateral costal; (9) the superior epigastric; and (10) the musculo-phrenic.

(1) The **pericardio-phrenic** or **superior phrenic** is a long slender vessel which comes off from the internal mammary just after it has entered the chest, and descends with the phrenic nerve, at first between the pleura and innominate vein; then between the pleura and the vena cava superior; and lastly, between the pleura and the pericardium to the diaphragm, where it anastomoses with the other diaphragmatic arteries. It gives branches both to the pleura and pericardium.

FIG. 424.—SCHEME OF THE RIGHT INTERNAL MAMMARY ARTERY. (Walsham.)


Common carotid artery
PHRENIC NERVE
Internal jugular vein
Subclavian artery
Subclavian vein, cut
Subclavian vein, cut
Scalenus anterior muscle
STERNUM
Transversus thoracis muscle
Anterior intercostal branch
Perforating branch
Anterior intercostal branch
Superior epigastric artery
Musculo-phrenic artery
Inferior epigastric artery
Deep circumflex iliac artery

(2) The **anterior mediastinal** and **thymic branches** come off irregularly from the internal mammary. They are of small size, and supply the connective tissue, fat, and lymphatics in the superior and anterior mediastina and the remains of the thymus gland.

(3) The **bronchial branches** are often wanting. When present they are supplied to the bronchi and the lower part of the trachea.

(4) The **pericardiac branches** are distributed to the anterior surface of the pericardium.

(5) The **sternal branches** enter the nutrient foramina in the sternum, and also supply the transversus thoracis (triangularis sterni).

(6) The **anterior intercostal arteries** (figs. 425, 443)—two in each of the five or six upper intercostal spaces—run outwards from the internal mammary artery,

along the lower border of the above and the upper border of the rib below, and anastomose with the corresponding upper and lower branches of the aortic intercostals. Each pair of branches sometimes arises by a common trunk from the internal mammary, which in this case soon divides into an upper and a lower branch, as above described. They lie at first between the internal intercostal muscles and the pleura; afterwards between the external and internal intercostal muscles. They supply the contiguous muscles, the pectoralis major, and the ribs.

(7) The **perforating** or **anterior perforating branches**—five or six in number, one corresponding to each of the five or six upper spaces—come off from the front of the internal mammary, between the superior and inferior anterior intercostals, and, perforating the internal intercostal muscles, pass forwards between the costal cartilages to the pectoralis major, which they supply. The terminal twigs perforate that muscle close to the sternum, and are distributed to the integument. The **second, third,** and **fourth perforating** supply the inner and deep surface of the mammary gland, and become greatly enlarged during lactation. They frequently require ligation in excision of the breast.

(8) The **lateral costal artery** is given off close to the first rib, and descends behind the ribs just external to the costal cartilages. It anastomoses with the upper intercostal arteries. This vessel is often of insignificant size, or absent.

(9) The **superior epigastric artery** (fig. 424), or internal terminal branch of the internal mammary artery, leaves the thorax behind the seventh costal cartilage by passing through the costo-xiphoid space in the diaphragm. It is the direct prolongation of the internal mammary downwards. In the abdomen it descends behind the rectus muscle, between its posterior surface and its sheath, and, lower, entering the substance of the muscle, anastomoses with the deep epigastric, a branch of the external iliac. It gives off the following small branches:—(*a*) The **phrenic,** to the diaphragm; (*b*) the **xiphoid,** which crosses in front of the xiphoid cartilage, and anastomoses with the artery of the opposite side; (*c*) the **cutaneous,** which perforate the anterior layer of the sheath of the rectus and supply the integuments; (*d*) the **muscular,** to the rectus muscle, some of which perforate the rectus sheath laterally, and are distributed to the oblique muscles; (*e*) the **hepatic** (on the right side only), which pass along the falciform ligament to the liver, and anastomose with the hepatic artery; (*f*) the **peritoneal,** which perforate the posterior layer of the sheath of the rectus, and ramify on the peritoneum.

(10) The **musculo-phrenic,** or external terminal branch of the internal mammary artery, skirts outwards and downwards behind the costal cartilages of the false ribs along the costal attachments of the diaphragm, which it perforates opposite the ninth rib. It terminates, much reduced in size, at the tenth or eleventh intercostal space by anastomosing with the ascending branch of the deep circumflex iliac artery. It gives off in its course the following small branches:—(*a*) The **phrenic** for the supply of the diaphragm; (*b*) the **anterior intercostals,** two in number for each of the lower five or six intercostal spaces, are distributed like those to the upper spaces, already described, and anastomose like them with the corresponding branches of the lower aortic intercostals; (*c*) the **muscular** for the supply of the oblique muscles of the abdomen.

BRANCHES OF THE SECOND PART OF THE SUBCLAVIAN ARTERY

THE COSTO-CERVICAL TRUNK

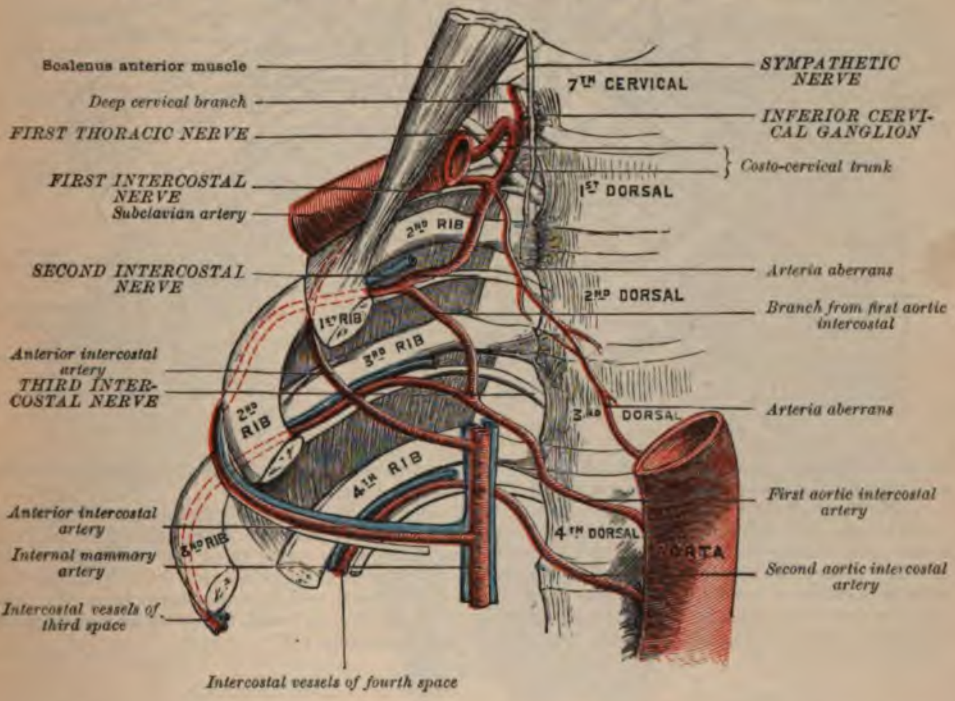
The **costo-cervical (superior intercostal) trunk** (figs. 406, 425) is a short stem which arises usually from the back part of the second portion of the subclavian artery, behind the scalenus anterior on the right side, but usually just internal to that muscle on the left side. Its course is upwards and backwards above the dome of the pleura and then downwards towards the thorax, before entering which it divides into its two terminal branches (1) the superior intercostal and (2) the deep cervical.

(1) The **superior intercostal** continues the direction of the costo-cervical trunk, passing downwards into the thorax in front of the neck of the first rib. It usually terminates opposite the first intercostal space by becoming the first intercostal artery, but frequently it is prolonged downwards over the neck of the second rib and terminates by uniting with the second aortic intercostal. As it crosses

the neck of the first rib the superior intercostal lies anterior (ventral) to the first intercostal nerve and lateral to the superior thoracic ganglion of the sympathetic. Its branches are: (1) the **first intercostal artery,** which runs forward in the first intercostal space and resembles in its course and distribution the succeeding intercostals derived from the thoracic aorta (see p. 581); (2) the **arteria aberrans,** which when present arises from the inner side of the right superior intercostal, or occasionally from the right subclavian itself. It descends as a slender vessel into the thorax, passing downwards and medially behind the œsophagus as far as the third or fourth thoracic vertebra, where in some cases it anastomoses with a similar slender branch arising from the aorta below the ligamentum arteriosum. This anastomosis represents the remains of the embryonic right aortic arch and it is by its occasional enlargement that the anomaly of the right subclavian artery arising from the descending portion of the aortic arch occurs (see p. 510).

(2) The **deep cervical branch** passes directly backwards, first between the seventh and eighth cervical nerves, and then between the transverse process of the seventh cervical vertebra and the neck of the first rib, having the body of the seventh cervical vertebra to its inner side, and the intertransverse muscle to its outer side. It then turns upwards in the groove between the transverse and spinous processes of the cervical vertebræ lying upon the semispinalis colli. It is covered by the semispinalis capitis (complexus). Between these muscles, near the axis, it anastomoses with the deep branch of the descending branch (princeps cervicis) of the occipital artery. The deep cervical is homologous in its course to the posterior branch of an aortic intercostal, being morphologically the posterior branch of the intercostal artery for the seventh cervical space. It gives off the following small branches:—(*a*) **Muscular,** to the semispinalis colli and capitis; (*b*) **anastomotic,** which anastomose with branches of the vertebral and ascending cervical arteries and with the descending branch (princeps cervicis) of the occipital; and (*c*) **vertebral** or **spinal,** which enters the spinal canal through the intervertebral foramen with the eighth cervical nerve.

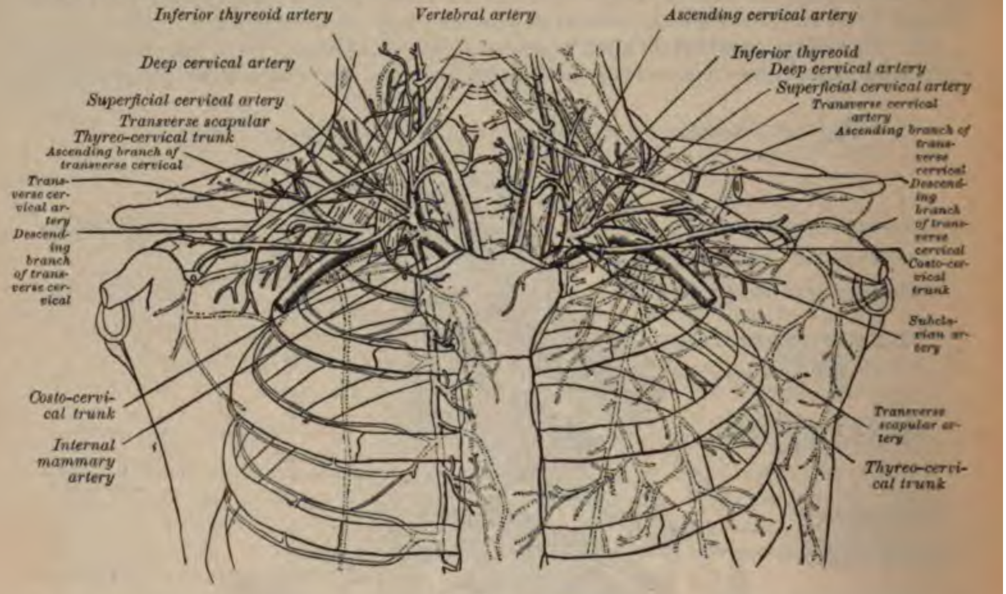
FIG. 425.—SCHEME OF THE RIGHT COSTO-CERVICAL TRUNK. (Walsham.)


Scalenus anterior muscle
Deep cervical branch
FIRST THORACIC NERVE
FIRST INTERCOSTAL NERVE
Subclavian artery
SECOND INTERCOSTAL NERVE
Anterior intercostal artery
THIRD INTERCOSTAL NERVE
Anterior intercostal artery
Internal mammary artery
Intercostal vessels of third space
Intercostal vessels of fourth space
SYMPATHETIC NERVE
7TH CERVICAL
INFERIOR CERVICAL GANGLION
Costo-cervical trunk
1ST DORSAL
2ND RIB
Arteria aberrans
2ND DORSAL
Branch from first aortic intercostal
1ST RIB
3RD RIB
2ND RIB
Arteria aberrans
3RD DORSAL
4TH RIB
First aortic intercostal artery
4TH DORSAL
3RD RIB
AORTA
Second aortic intercostal artery

Variations of the Branches of the Subclavian Artery

There is considerable variation in the branches of the subclavian artery and Bean has shown that the branches are arranged in a different way on the two sides of the body. The usual form on the right side is for the vertebral, internal mammary, the superficial cervical and the common trunk of the inferior thyreoid and transverse scapular arteries to arise from the first part of the subclavian. In this case the ascending cervical is a branch of the inferior thyreoid, while the transverse cervical and costo-cervical arise from the second portion. There are no branches from the third portion. On the left side the usual form is for the vertebral and internal mammary, and thyreo-cervical trunk, to arise from the first part. The thyreo-cervical trunk divides into inferior thyreoid, transverse scapular, and transverse cervical arteries; the superficial cervical is absent, and the costo-cervical trunk arises from the first part.

Fig. 426.—The Normal Arrangement of the Subclavian Artery. (After Bean.)


Inferior thyreoid artery
Vertebral artery
Ascending cervical artery
Deep cervical artery
Superficial cervical artery
Transverse scapular
Thyreo-cervical trunk
Ascending branch of transverse cervical
Transverse cervical artery
Descending branch of transverse cervical
Costo-cervical trunk
Internal mammary artery
Inferior thyreoid
Deep cervical artery
Superficial cervical artery
Transverse cervical artery
Ascending branch of transverse cervical
Descending branch of transverse cervical
Costo-cervical trunk
Subclavian artery
Transverse scapular artery
Thyreo-cervical trunk

There are three more types of origin of the branches; in one, the vertebral, internal mammary, costo-cervical, and inferior thyreoid come from the first part, while the transverse cervical arises from the second part, and the transverse scapular comes either from the third part or the axillary artery; in the second, the inferior thyreoid, transverse scapular and transverse cervical arise in a common stem from the first part; while in the third, which is the rarest form, the inferior thyreoid and superficial cervical arteries come by a common trunk from the first part, while the transverse scapular artery arises from the internal mammary.

THE AXILLARY ARTERY

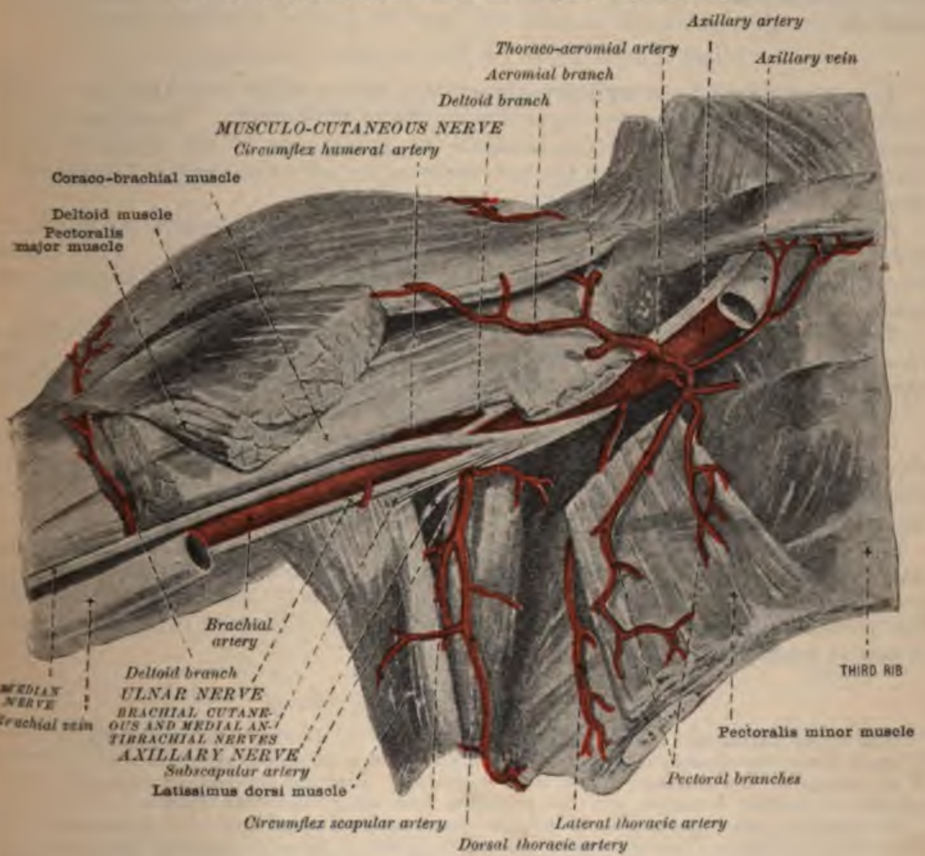
The term axillary is applied to that portion of the main arterial stem of the upper limb that passes through the axillary fossa. The axillary artery therefore is continuous with the subclavian above and with the brachial below. It extends from the outer border of the first rib to the lower edge of the teres major muscle, and has the shoulder-joint and the neck of the humerus to its outer side. When the arm is placed close to the side of the body, the artery forms a gentle curve with its convexity upwards; but when the arm is carried out from the side at right angles to the trunk in the ordinary dissecting position, the vessel takes a nearly straight course, which will then be indicated by a line drawn from the middle of the clavicle to a spot midway between the epicondyles of the humerus. The axillary artery is at first deeply placed beneath the pectoral muscles, but in its lower third it is superficial, being covered only by the skin and the superficial fascia and deep fascia. It is divided into three parts, first, second, and third, according as it lies respectively above, beneath, or below the pectoralis minor.

THE FIRST PART OF THE AXILLARY ARTERY

The **first part of the axillary artery** extends from the outer border of the first rib to the upper border of the pectoralis minor. It measures about 2.5 cm. (1 in.) in length.

Relations.—**In front** it is covered by the skin, superficial fascia, the origin of the platysma, the deep fascia, the pectoralis major, the coraco-clavicular (costo-coracoid) fascia, the subclavius muscle and the clavicle when the arm hangs down

FIG. 427.—THE AXILLARY ARTERY. (After Spalteholz.)


Axillary artery
Thoraco-acromial artery
Axillary vein
Acromial branch
Deltoid branch
MUSCULO-CUTANEOUS NERVE
Circumflex humeral artery
Coraco-brachial muscle
Deltoid muscle
Pectoralis major muscle
Brachial artery
Deltoid branch
MEDIAN NERVE
ULNAR NERVE
Brachial vein
BRACHIAL CUTANEOUS AND MEDIAL ANTIBRACHIAL NERVES
AXILLARY NERVE
Subscapular artery
Latissimus dorsi muscle
Circumflex scapular artery
Dorsal thoracic artery
Lateral thoracic artery
Pectoral branches
Pectoralis minor muscle
THIRD RIB

y the side. The cephalic and thoraco-acromial veins, the external anterior thoacic nerve, and the axillary lymphatic trunk, cross over it. A layer of the deep ervical fascia which has passed under the clavicle also descends in front of it.

Behind, it rests upon the first intercostal space and first intercostal muscle, he first digitation and sometimes a portion of the second digitation of the serratus nterior (magnus) muscle, and a part of the second rib. The long thoracic nerve, n its way to the serratus anterior muscle, passes behind it.

To its **outer side,** and somewhat on a higher plane, are the cords of the brachial lexus.

To its **inner side,** and on a slightly anterior plane, is the axillary vein. The nternal anterior thoracic nerve courses between the vein and the artery.

THE SECOND PART OF THE AXILLARY ARTERY

The **second part of the axillary artery** (fig. 427) lies beneath the pectoralis minor deep in the axilla. It measures 3 cm. (a little more than 1 in.) in length.

Relations.—In front, in addition to the pectoralis minor, it is covered by the pectoralis major and the integuments.

Behind, it is separated by a considerable interval, containing loose connective tissue and fat, from the subscapularis muscle; whilst behind, and in contact with it, is the posterior cord of the brachial plexus.

To the **inner side,** but separated from the artery by the inner cord of the brachial plexus, is the axillary vein.

To the **outer side** is the outer cord of the brachial plexus, and at some little distance the coracoid process.

It is thus seen that the second portion of the axillary artery is surrounded on three sides by the cords of the brachial plexus—one behind, one internal, and one external.

THE THIRD PART OF THE AXILLARY ARTERY

The **third part of the axillary artery** (fig. 427) extends from the lower border of the pectoralis minor to the lower border of the teres major. Its upper half lies deeply placed within the axilla, beneath the lower edge of the pectoralis major muscle, but its lower half is in the arm external to the axilla, and is uncovered by muscle. It measures about 7·5 cm. (3 in.) in length.

Relations.—In front it has, in addition to the skin and superficial fascia, the pectoralis major above, and lower down the deep fascia of the arm. It is crossed obliquely by the inner root of the median nerve and by the outer brachial vena comes.

Behind, it lies successively upon the subscapularis, the latissimus dorsi, and teres major muscles. From the first-named muscle it is separated at first by a considerable mass of fat and cellular tissue. The radial (musculo-spiral) and axillary (circumflex) nerves intervene between the artery and the muscles.

On its **outer side** it is separated from the bone by the coraco-brachialis, by which it is partly overlapped, this muscle and the short head of the biceps serving as a guide to the artery in ligature. For a part of its course it has also the musculo-cutaneous nerve and the outer root of the median nerve to its outer side.

To its **inner side** it has the axillary vein, the ulnar nerve, the medial antibrachial (internal) and brachial (lesser internal) cutaneous nerves, and the inner root of the median nerve. The ulnar nerve is between the artery and the vein. The medial antibrachial (internal) cutaneous nerve is a little in front of the artery as well as internal to it.

Variations in the Axillary Artery

The **chief variations in the axillary artery** are:—(*a*) It may give off the radial artery; (*b*) more rarely, the ulnar artery; (*c*) still more rarely, the interosseous artery, or a **vas aberrans;** (*d*) it may give off a common trunk, from which may arise the subscapular, the anterior and posterior circumflex humeral, and the profunda and ulnar collateral arteries. The branches of the brachial plexus usually surround this common trunk, and not what is apparently the main brachial artery. The latter vessel indeed would seem in many of these instances to be really an enlarged vas aberrans, and the common trunk the main brachial artery, the lower portion of which has been obliterated, i.e. obliterated from the last branch given off from the common trunk to the spot where it is again joined by the vas aberrans. (*e*) The axillary artery may be covered in the third part of its course by a muscular slip (the **axillary arch**) derived from the upper part of the tendon of the latissimus dorsi, and always present in early fœtal life, though as a rule atrophied later.

BRANCHES OF THE AXILLARY ARTERY

The branches of the axillary artery are exceedingly variable. In fig. 428 is shown what Hitzrot has found the usual type, in which the second portion of the artery has no branches. The figure brings out the segmental relation of the branches of the axillary artery to the chest wall and suggests how one of the branches may supply the place of another. The branches may occur as follows:

The **first part** gives off.—(1) The superior thoracic; and (2) the thoraco-acromial

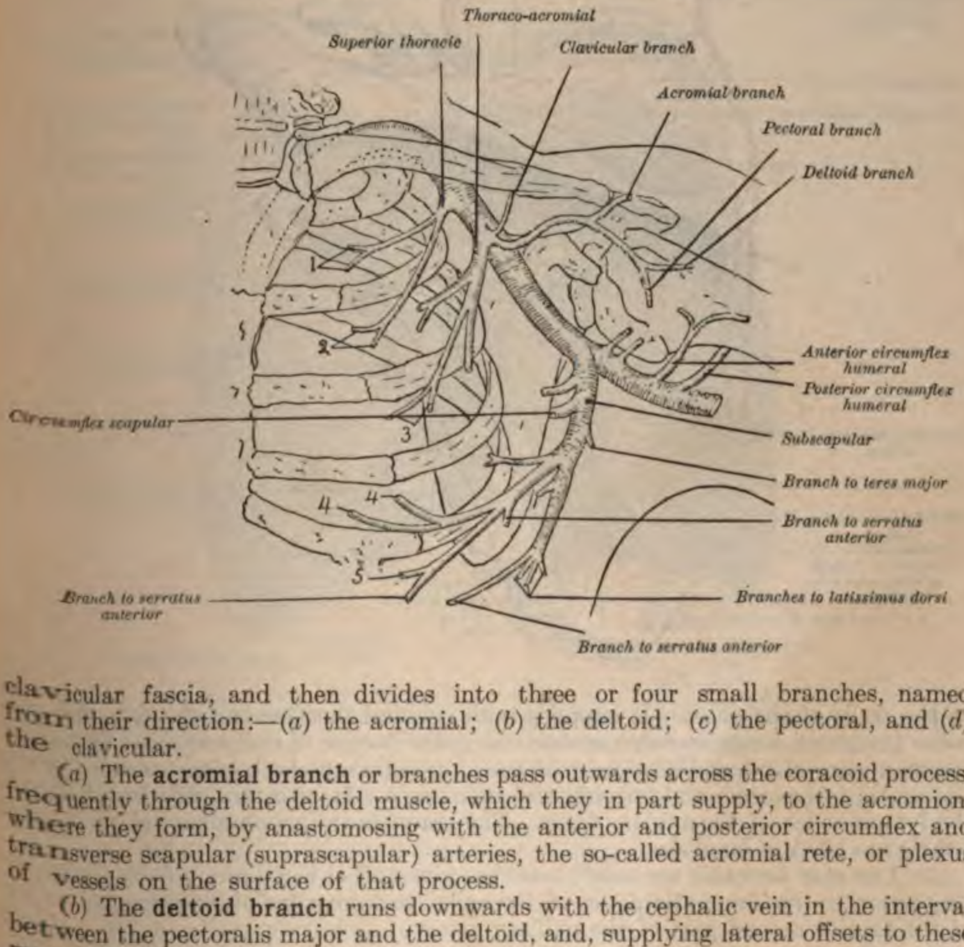
The **second part** gives off:—(1) The lateral thoracic; and (2) the alar thoracic.
The **third part** gives off:—(1) The subscapular; (2) the anterior humeral circumflex; (3) the posterior humeral circumflex; and (4) muscular branches.

BRANCHES OF THE FIRST PART OF THE AXILLARY ARTERY

1. The **superior thoracic** is variously given off from the axillary artery, usually either as a common trunk with the next branch, the thoraco-acromial, or a little above. It passes behind the axillary vein across the first intercostal space, supplying the intercostal muscles and the upper portion of the serratus anterior, and anastomoses with the intercostal arteries. At times it sends a branch between the pectoralis major and minor, which then, as a rule, more or less takes the place of the pectoral branch of the thoraco-acromial (figs. 427 and 428).

2. The **thoraco-acromial (acromio-thoracic,** or **thoracic axis)** arises from the front part of the axillary just above the upper border of the pectoralis minor. It is a short trunk, and, coming off from the front of the artery, pierces the coraco-clavicular fascia, and then divides into three or four small branches, named from their direction:—(*a*) the acromial; (*b*) the deltoid; (*c*) the pectoral, and (*d*) the clavicular.

FIG. 428.—THE BRANCHES OF THE AXILLARY ARTERY. (After Hitzrot.)
The numbers 1-5 indicate the intercostal spaces.


Thoraco-acromial
Superior thoracic
Clavicular branch
Acromial branch
Pectoral branch
Deltoid branch
Anterior circumflex humeral
Posterior circumflex humeral
Circumflex scapular
Subscapular
Branch to teres major
Branch to serratus anterior
Branch to serratus anterior
Branches to latissimus dorsi
Branch to serratus anterior
1
2
3
4
4
5

(*a*) The **acromial branch** or branches pass outwards across the coracoid process, frequently through the deltoid muscle, which they in part supply, to the acromion, where they form, by anastomosing with the anterior and posterior circumflex and transverse scapular (suprascapular) arteries, the so-called acromial rete, or plexus of vessels on the surface of that process.

(*b*) The **deltoid branch** runs downwards with the cephalic vein in the interval between the pectoralis major and the deltoid, and, supplying lateral offsets to these muscles and the adjacent integument, anastomoses with the anterior and posterior circumflex humeral arteries.

(*c*) The **pectoral branch** passes between the pectoralis major and minor muscles, both of which it supplies. In the female, one or more branches which perforate the pectoralis major are often of large size, and supply the superimposed mammary gland.

(*d*) The **clavicular branch** passes upwards beneath the clavicle, supplies the subclavius muscle, and anastomoses with the transverse scapular artery.

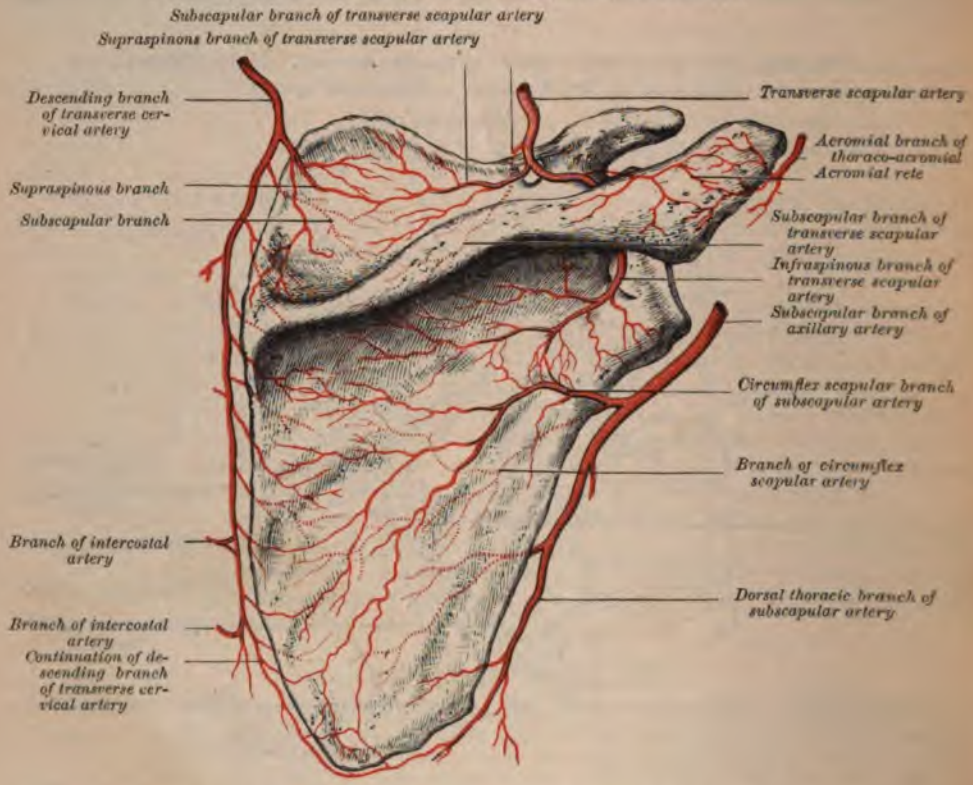
Variations.—Either the superior thoracic or the thoraco-acromial may be wanting. The first part of the axillary may in rare cases give off the subscapular artery, or a branch to the subscapular muscle, or it may have four branches, the superior thoracic, thoraco-acromial, accessory pectoral branches, and the lateral thoracic.

BRANCHES OF THE SECOND PART OF THE AXILLARY ARTERY

The second part has no branches in a large number of cases. It may give off the lateral thoracic and the alar thoracic. In a few cases it gives off the subscapular, or the thoraco-acromial.

1. The **lateral thoracic artery**—also called the external mammary—descends along the lower border of the pectoralis minor, under cover of the pectoralis major, to the walls of the chest. It supplies both pectoral muscles and the serratus anterior (magnus), sends branches around the lower border of the pectoralis major to the mammary gland, and terminates in the intercostal muscles by anastomosing with the aortic intercostals and the internal mammary. It also furnishes branches to the lymph-nodes of the axillary fossa. The branches to the mammary gland in the female are often of large size.

FIG. 429.—THE ANASTOMOSES ABOUT THE SCAPULA.


Subscapular branch of transverse scapular artery
Supraspinous branch of transverse scapular artery
Descending branch of transverse cervical artery
Supraspinous branch
Subscapular branch
Transverse scapular artery
Acromial branch of thoraco-acromial
Acromial rete
Subscapular branch of transverse scapular artery
Infraspinous branch of transverse scapular artery
Subscapular branch of axillary artery
Circumflex scapular branch of subscapular artery
Branch of circumflex scapular artery
Branch of intercostal artery
Dorsal thoracic branch of subscapular artery
Branch of intercostal artery
Continuation of descending branch of transverse cervical artery

2. The **alar thoracic** are small branches given off either directly from the axillary artery to the lymphatic nodes in the axilla, or from some of the other branches of the first or second part of the axillary artery.

BRANCHES OF THE THIRD PART OF THE AXILLARY ARTERY

1. The **subscapular artery** is the largest branch of the axillary. It arises opposite the lower border of the subscapularis, and runs downwards and inwards along the anterior border of that muscle under cover of the latissimus dorsi.

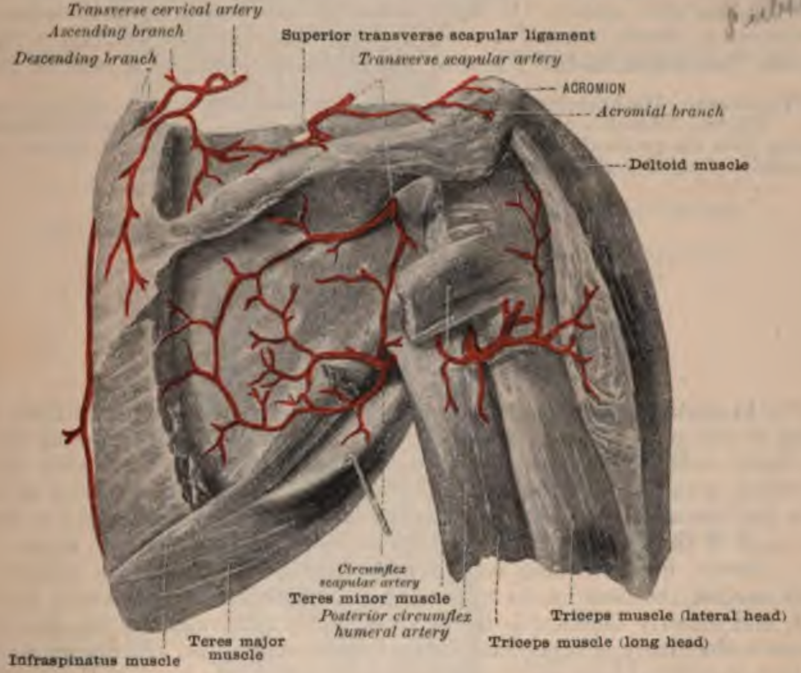
supplies the subscapularis, teres major, latissimus dorsi, and serratus anterior (magnus) muscles, and gives branches to the nodes in the axillary fossa. The course of this large vessel along the posterior border of the axillary fossa should be remembered in opening abscesses in the fossa, and in removing enlarged nodes from it. It is accompanied by two veins, which usually unite and then receive the circumflex (dorsal) scapular vein, and open as a single vein of large size either into the axillary or at the confluence of the inner brachial vena comes with the basilic vein.

About 2·5 or 3·7 cm. (1 or 1½ in.) from its origin, the subscapular artery divides into two end branches, (1) the circumflex (dorsal) scapular, and (2) the dorsal thoracic.

(1) The **circumflex (dorsal) scapular,** arising from the subscapular, usually at the above-mentioned spot, passes backwards through the triangular space bounded by the subscapularis above, the teres major below, and the long head of the triceps externally, and then between the teres minor and the axillary border of the scapula, which it commonly grooves. It thus reaches the infraspinous fossa, where, under cover of the infra-spinatus, it anastomoses with the transverse scapular (suprascapular) artery and the descending branch of the transverse cervical (posterior scapular) (fig. 429). As it passes through the triangular space, it gives off a ventral branch which ramifies between the subscapularis and the bone, supplying branches to the subscapularis, to the scapula, and to the shoulder-joint. A second branch is often given off near the triangular space and passes downwards between the teres major and teres minor, supplying both muscles (fig. 430).

subscapular { dorsal / circumf scap

FIG. 430.—THE ARTERIES OF THE SHOULDER. (After Spalteholz.)


Transverse cervical artery
Ascending branch
Descending branch
Superior transverse scapular ligament
Transverse scapular artery
ACROMION
Acromial branch
Deltoid muscle
Circumflex scapular artery
Teres minor muscle
Posterior circumflex humeral artery
Triceps muscle (lateral head)
Triceps muscle (long head)
Teres major muscle
Infraspinatus muscle

(2) The **dorsal thoracic** continues in the course of the subscapular as far as the angle of the scapula, where it anastomoses with the circumflex scapular, the descending branch of the transverse cervical (posterior scapular), the lateral thoracic, and intercostal arteries.

2. The **anterior circumflex humeral,** usually quite a small vessel, comes off from the outer side of the axillary artery, generally opposite the posterior circumflex. It passes beneath the coraco-brachialis and short and long heads of the biceps, winding transversely round the front of the surgical neck of the humerus, across the intertubercular (bicipital) groove, and anastomoses with the posterior circumflex and thoraco-acromial arteries. It gives off the following small branches: (*a*) the bicipital or ascending, which runs up the intertubercular groove to supply the long

tendon of the biceps and the shoulder-joint; and (*b*) a **pectoral** or descending branch, which runs downwards along the insertion of the pectoralis major, and supplies the tendon of that muscle. The anterior circumflex artery, in consequence of its being close to the bone, is sometimes difficult to secure in the operation for excision of the shoulder-joint.

(3) The **posterior circumflex humeral artery** (fig. 430) arises from the hinder part of the axillary, just below the lower border of the subscapularis muscle. It passes through the quadrilateral space, bounded by the teres minor above, the latissimus dorsi and teres major below, the humerus externally, and the long head of the triceps internally, and, winding round the back of the humerus beneath the deltoid, breaks up under cover of that muscle into a leash of branches, which for the most part enter its substance. The axillary (circumflex) nerve and two venæ comites run with it. It anastomoses with the anterior circumflex, the arteries on the acromion, and the profunda artery.

In addition to the leash of vessels to the deltoid, it gives off the following small branches:—(*a*) **nutrient,** to the greater tuberosity of the humerus; (*b*) **articular,** to the back of the shoulder-joint; (*c*) **acromial,** to the plexus on the acromion; and (*d*) **muscular,** to the teres minor and long and short heads of the triceps. One or more of these branches to the triceps descend either between the outer and long head or in the substance of that muscle, to anastomose with an ascending branch from the profunda artery. It is by means of this anastomosis that the collateral circulation is chiefly carried on when the axillary or the brachial artery is tied between the origins of the posterior circumflex and profunda arteries (fig. 406).

Variations.—The branches of the third part of the axillary artery are subject to great variations. The two circumflex arteries may come off from a common trunk, usually alone, or rarely together with the profunda and muscular branches. The two circumflex arteries together, or the anterior circumflex alone may be the only branch of the third part.

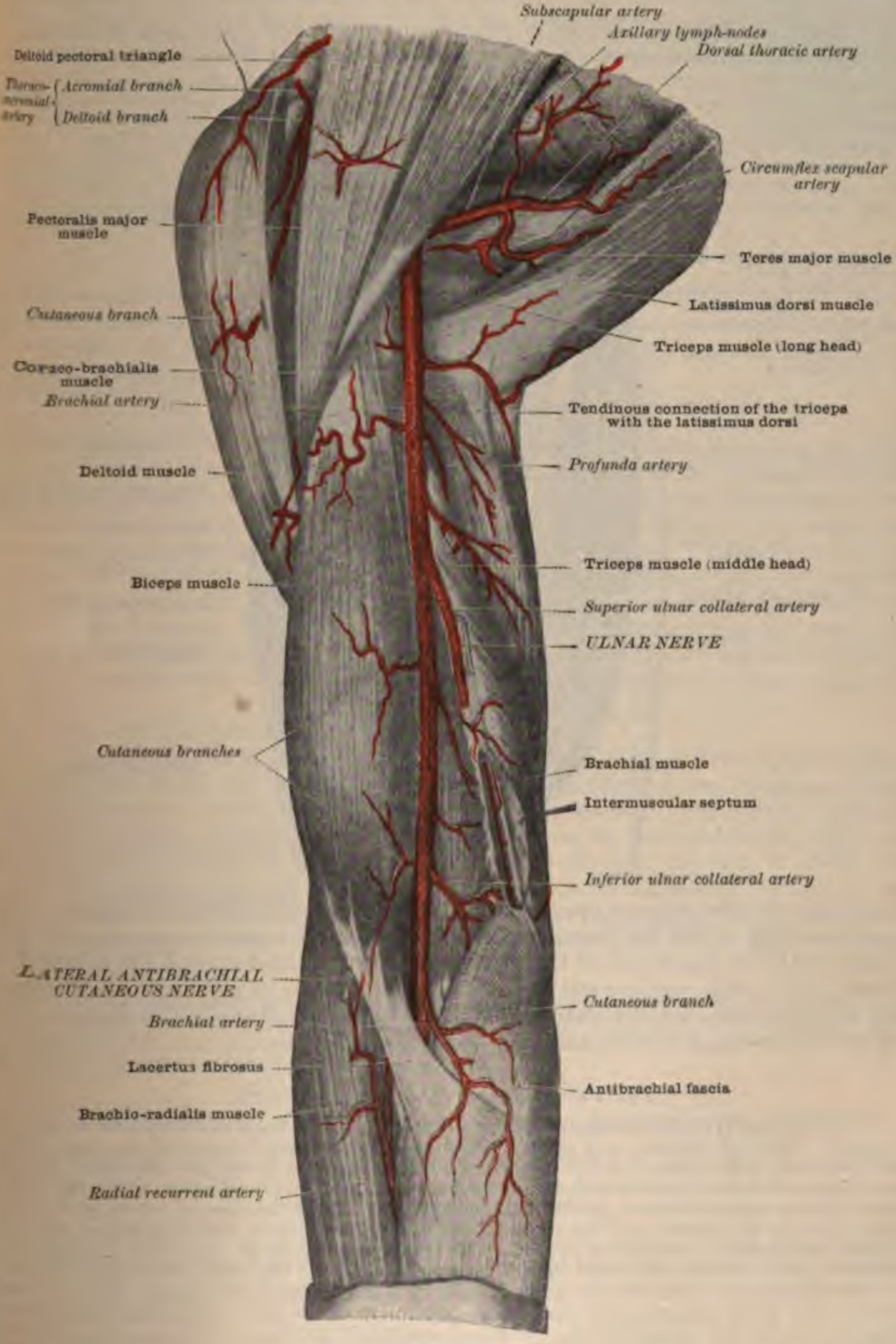
THE BRACHIAL ARTERY

The **brachial artery,** the continuation of the axillary, extends from the lower border of the teres major to a little below the centre of the crease at the bend of the elbow, where it divides, opposite the junction of the head with the neck of the radius, into the radial and ulnar arteries. The artery is situated at first internal to the humerus; but as it passes down the arm it gradually gets in front of the bone, and at the bend of the elbow lies midway between the two epicondyles (fig. 431). Hence, in controlling hæmorrhage, the artery should be compressed outwards against the bone in its upper third, outwards and backwards in its middle third, and directly backwards in its lower third. Throughout the greater part of its course the artery is superficial, being merely overlapped slightly on its outer side by the coraco-brachialis and biceps muscles; but at the bend of the elbow it sinks deeply beneath the lacertus fibrosus of the biceps into the triangular interval (antecubital space) bounded on either side by the brachio-radialis and pronator teres, and at its bifurcation is more or less under cover of these muscles (fig. 431). The sheath of the brachial artery is closely incorporated with the fascia covering the biceps muscle, and it is for this reason that in the operation for ligaturing the vessel is apt to be retracted with the muscle. A line drawn from midway between the folds of the axilla at the outer side of that space to midway between the epicondyles of the humerus will indicate its course. It is accompanied by two veins which frequently communicate across the artery.

Relations.—**In front,** the artery is covered by the integument and superficial and deep fasciæ, and at the bend of the elbow by the lacertus fibrosus of the biceps, and in muscular subjects by the overlapping margins of the brachio-radialis and pronator teres. In the middle third of the arm it is crossed obliquely from without inwards by the median nerve, and at the bend of the elbow by the median vein, the bicipital fascia intervening (fig. 438).

Behind, it lies successively on the long head of the triceps (from which it separated by the radial (musculo-spiral) nerve and profunda artery), on the inner head of the triceps, on the insertion of the coraco-brachialis, and thence to its bifurcation on the brachialis muscle.

Fig. 431.—The Brachial Artery. (After Toldt, "Atlas of Human Anatomy" Rebman, London and New York.)

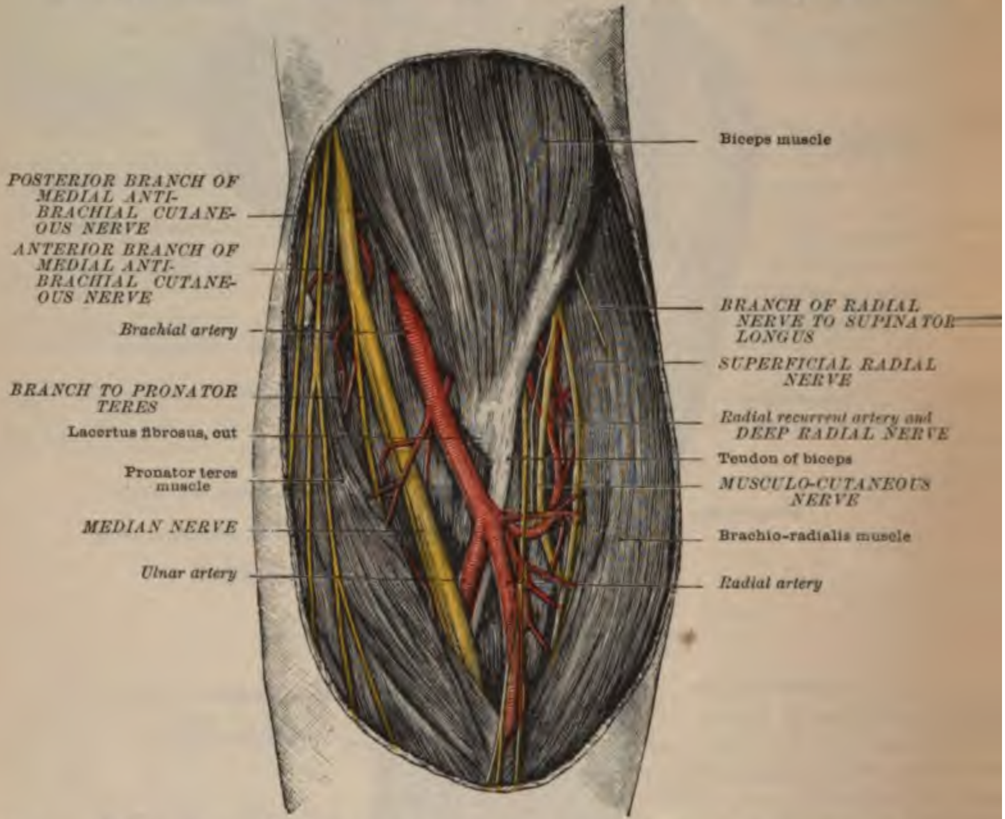

Subscapular artery
Axillary lymph-nodes
Dorsal thoracic artery
Deltoid pectoral triangle
Thoraco-acromial artery
Acromial branch
Deltoid branch
Circumflex scapular artery
Pectoralis major muscle
Teres major muscle
Latissimus dorsi muscle
Cutaneous branch
Triceps muscle (long head)
Coraco-brachialis muscle
Brachial artery
Tendinous connection of the triceps with the latissimus dorsi
Deltoid muscle
Profunda artery
Triceps muscle (middle head)
Biceps muscle
Superior ulnar collateral artery
ULNAR NERVE
Cutaneous branches
Brachial muscle
Intermuscular septum
Inferior ulnar collateral artery
LATERAL ANTIBRACHIAL CUTANEOUS NERVE
Cutaneous branch
Brachial artery
Lacertus fibrosus
Antibrachial fascia
Brachio-radialis muscle
Radial recurrent artery

External to the artery is the coraco-brachialis above, and the muscular belly of he biceps below, both of which slightly overlap the vessel, and at the bend of the lbow the tendon of the biceps. The external vena comes is also to its outer side.

The median nerve is in close contact with the outer side of the artery in the upper third of its course, but in the middle third crosses the artery obliquely to gain the inner side.

Internal to the artery in the upper part of its course are the medial antibrachial (internal) cutaneous and the ulnar nerves; the latter nerve, however, leaves the artery about the origin of the ulnar collateral (inferior profunda) branch, to make, with that vessel, for the internal epicondyle. Lower down, the internal cutaneous nerve also leaves the artery, by piercing the deep fascia. The median nerve is in close contact with the inner side of the artery in its lower third and at the bend of the elbow. The basilic vein is superficial to it, and a little to its inner side in the greater part of its course, but separated from it by the deep fascia. The internal vena comes runs along its inner side.

FIG. 432.—THE BRACHIAL ARTERY AT THE BEND OF THE ELBOW, LEFT SIDE, FRONT VIEW. (From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)


Biceps muscle
POSTERIOR BRANCH OF MEDIAL ANTIBRACHIAL CUIANEOUS NERVE
ANTERIOR BRANCH OF MEDIAL ANTIBRACHIAL CUTANEOUS NERVE
BRANCH OF RADIAL NERVE TO SUPINATOR LONGUS
Brachial artery
SUPERFICIAL RADIAL NERVE
BRANCH TO PRONATOR TERES
Radial recurrent artery and DEEP RADIAL NERVE
Lacertus fibrosus, cut
Tendon of biceps
Pronator teres muscle
MUSCULO-CUTANEOUS NERVE
MEDIAN NERVE
Brachio-radialis muscle
Ulnar artery
Radial artery

The Variations in the Brachial Artery

The **chief variations in the brachial artery** are:—(1) **A high division** into its terminal branches. The high division may occur at any spot in the normal course of the vessel, but is most common in the upper third of the arm, and least common in the middle third. The two vessels into which the brachial then divides as a rule run parallel to each other to the bend of the elbow in the usual situation of the brachial, whence one follows the normal course of the radial artery through the forearm, and the other takes the normal course of the ulnar artery, giving off as usual the common interosseous artery. This arrangement may be considered a **simple high division** of the brachial. At other times the disposition of the two vessels is different: thus (i) the two arteries may communicate at the elbow by a cross branch, or reunite, and then again divide in the usual manner. (ii) One vessel may follow the course of the ulnar artery in the forearm, and the other divide into the radial and common interosseous. This condition is spoken of as a high origin of the ulnar. (iii) One artery may divide into the radial and ulnar as usual, and the other take the course of the common interosseous and divide into the anterior and posterior interosseous arteries; or, much more rarely, take the course of the posterior interosseous artery, the anterior interosseous coming from the ulnar. (iv) The vessels may follow a course in the upper arm different from that of the normal brachial. Thus (A) the branch representing

1. middle coll [illegible]

and coll [illegible] ulnar [illegible]

[illegible] ulnar coll [illegible]

the radial may (a) cross over or under the other branch; (b) perforate the deep fascia above the elbow, and run beneath the skin to its place in the forearm; or (c) pass behind the tendon of the biceps. (B) The branch representing the ulnar may (a) run to the front of the inner epicondyle with the median nerve, and thence reach its usual situation by descending from within outwards beneath the fascia and pronator teres, or, more rarely, beneath some of the flexor muscles, or merely beneath the skin; or (b) it may run with the ulnar nerve behind the inner epicondyle, and thence beneath the muscles to its usual place in the forearm. (2) An **enlarged vas aberrans** may be present. This is a long slender vessel, which arises from the brachial usually near the origin of the profunda, and joins most commonly the radial artery, or, more rarely, one of its branches, or the ulnar. It is said to be usually present, though not admitting of complete injection, and to descend over the median nerve to the biceps muscle. At times this vessel takes the place of the brachial; the median nerve will then be found behind the artery. (3) The brachial may run with the median nerve towards the inner epicondyle, where it then usually turns round a supracondyloid process after the course normally taken by the artery in the Felidæ, in which it runs through a supracondyloid foramen. Thence it descends to its normal situation beneath the pronator teres, which then usually arises from a fibrous expansion from the process. (4) The brachial may be covered by various muscular slips derived from the adjacent muscles. (5) Certain abnormalities in the giving off of its collateral branches. These are referred to under each branch.

BRANCHES OF THE BRACHIAL ARTERY

The **branches of the brachial artery** are:—(1) The profunda; (2) the superior ulnar collateral (inferior profunda); (3) the inferior ulnar collateral (anastomotica magna); and (4) the terminal branches—the radial and ulnar arteries.

(1) THE PROFUNDA ARTERY

The **profunda** or **superior profunda** is the largest of the branches of the brachial. It arises from the inner and hinder aspect of that artery, a little below the inferior border of the tendon of the teres major. It at first lies to the inner side of the brachial, but soon passes behind that vessel, and, sinking between the inner and long heads of the triceps with the radial (musculo-spiral) nerve, curves around the humerus in the groove for the nerve, lying in contact with the bone between the inner and outer heads of the triceps. On reaching the external supracondyloid ridge of the humerus it perforates the external intermuscular septum, and, continuing forwards between the brachio-radialis and brachialis to the front of the external epicondyle, ends by anastomosing with the radial recurrent artery (figs. 431 and 437).

It gives off the following branches:—

(a) **The deltoid,** which may also arise from the brachial itself or from the superior ulnar collateral. It runs across the anterior surface of the humerus, under cover of the coraco-brachialis and biceps, and supplies the brachialis and deltoid.

(b) The **middle collateral** runs in the substance of the middle head of the triceps as far as the elbow, where it terminates in the articular rete. Rete

(c) The **radial collateral** or **articular** arises about the middle of the upper arm, and runs behind the lateral intermuscular septum to the rete at the elbow-joint.

(d) A **nutrient** branch, which may come from the brachial itself or from a muscular branch, enters a canal in the humerus.

Chief variations.—The **profunda** may arise (a) from the axillary artery in common with one or more branches of that vessel; or (b) as a common trunk with the superior ulnar collateral (inferior profunda). (c) It may give off the posterior circumflex, which then runs upwards behind the teres major to reach the back of the shoulder.

(2) THE SUPERIOR ULNAR COLLATERAL (INFERIOR PROFUNDA) ARTERY

The **superior ulnar collateral** or **inferior profunda** arises from the inner side of the brachial, usually about the level of the insertion of the coraco-brachialis, at times as a common trunk with the profunda. It passes with the ulnar nerve obliquely downwards and inwards through the internal intermuscular septum, and then along the inner head of the triceps to the back of the internal epicondyle, where, under cover of the deep fascia and the origin of the flexor carpi ulnaris from the olecranon and internal epicondyle, it enters into the anastomoses around the elbow-joint. It frequently supplies the nutrient artery to the humerus. It gives branches to the triceps, to the elbow-joint, and a branch which passes in front of the internal epicondyle to anastomose with the anterior ulnar recurrent. 3 Rete

Chief variations.—(1) The **superior ulnar collateral** may arise (a) with the profunda; (b) from a trunk common to several other branches of the axillary and brachial arteries. (2) It may be absent, its place being taken by the inferior ulnar collateral.

(3) THE INFERIOR ULNAR COLLATERAL (ANASTOMOTICA MAGNA) ARTERY

The **inferior ulnar collateral** or **anastomotica magna** arises from the inner side of the brachial, about 5 cm. (2 in.) above its bifurcation into the radial and ulnar arteries, and, running downwards and inwards across the brachialis, divides into two branches, a posterior and an anterior. The **posterior** pierces the internal intermuscular septum, winds round the internal condyloid ridge of the humerus, and pierces the triceps, between which and the bone it anastomoses with the articular branch of the profunda artery, and to a lesser extent with the interosseous recurrent, forming an arterial arch or rete around the upper border of the olecranon fossa. The **anterior** branch passes downwards and inwards between the brachialis and pronator teres, and anastomoses in front of the internal epicondyle, but beneath the pronator teres, with the anterior ulnar recurrent. From this branch a small vessel passes down behind the internal epicondyle to anastomose with the posterior ulnar recurrent and superior ulnar collateral arteries (fig. 437).

Chief variations.—(*a*) The **inferior ulnar collateral** may take the place of the superior ulnar collateral. (*b*) It may be very small, the superior taking its place.

(4) THE NUTRIENT ARTERY OF THE HUMERUS

The **nutrient artery of the humerus** comes off from the brachial about the level of the insertion of the coraco-brachialis, or from the superior ulnar collateral, or from one of the muscular branches. It passes obliquely downwards through the nutrient foramen, and on entering the medullary canal of the humerus divides into an ascending and a descending branch, of which the latter is the larger.

(5) THE MUSCULAR BRANCHES OF THE BRACHIAL

The **muscular branches** are irregular in their number, origin, and distribution. They vary from about five to eight, usually come off from the outer part of the artery, and are distributed to the coraco-brachialis, biceps, and brachialis muscles. The nutrient artery of the humerus frequently arises from the uppermost muscular branch.

THE ULNAR ARTERY

The **ulnar artery,** the larger of the two terminal branches of the brachial, begins opposite the lower border of the head of the radius in the middle line of the forearm. Thence through the upper half of the forearm it runs beneath the pronator teres and superficial flexor muscles, and, having reached the ulnar side of the arm about midway between the elbow and the wrist, it passes directly downwards, being merely overlapped by the flexor carpi ulnaris. Crossing the transverse carpal (anterior annular) ligament immediately to the radial side of the pisiform bone, it enters the palm, where it divides into two branches, which enter respectively into the formation of the superficial and deep palmar arches. The artery is accompanied by two veins, which anastomose with each other by frequent cross branches, and usually terminate in the brachial venæ comites; or sometimes the inner vena comes ends in the inner brachial vein, the outer vena comes in the median cubital vein. The ulnar nerve is at first some distance from the artery, but approaches the vessel at the junction of its upper and middle thirds, and then lies close to its inner or ulnar side. The course of the artery in the lower two-thirds of the forearm is indicated by a line drawn from the front of the internal epicondyle to the radial side of the pisiform bone; and in the upper third of the forearm by a line drawn in a gentle curve with its convexity inwards from 2·5 cm. (1 in.) below the centre of the bend of the elbow to a point in the former line at the junction of its upper with its middle third. The artery throughout its course is best reached through the innermost intermuscular septum, i.e., the interval between the flexor carpi ulnaris and the flexor digitorum sublimis.

The relations of the artery will be given in detail—as it lies in the forearm, at the wrist, and in the palm of the hand.

I. RELATIONS OF THE ULNAR ARTERY IN THE FOREARM

In front.—In the upper half of the forearm the ulnar artery is deeply placed beneath the pronator teres, the flexor carpi radialis, the palmaris longus, and the flexor digitorum sublimis. In the lower half it is comparatively superficial, being merely overlapped above by the tendon of the flexor carpi ulnaris, whilst the last inch or so of the vessel is only covered as a rule by the skin and superficial and deep fasciæ. As the artery lies beneath the pronator teres, it is crossed from within outwards by the median nerve, the deep head of origin of the muscle usually separating the nerve from the artery. The lower part of the artery is crossed by the palmar cutaneous branch of the ulnar nerve.

Behind.—For about 2·5 cm. (1 in.) of its course the artery lies upon the brachialis; but thence, as far as the transverse carpal (anterior annular) ligament, upon the flexor digitorum profundus, which separates it above from the interosseous membrane and bone, and at the wrist from the pronator quadratus. The artery is bound down to the flexor digitorum profundus by bands of fasciæ.

To the **outer side** in the lower two-thirds of its course is the flexor digitorum sublimis.

To the **inner side** in the lower two-thirds is the flexor carpi ulnaris, the guide to the vessel. The ulnar nerve, as it enters the forearm from behind the inner condyle, is at first some distance from the artery, being separated from it in its upper third by the flexor digitorum sublimis, but in its lower two-thirds is in close contact with the vessel and on its ulnar side.

Variations of the Ulnar Artery in the Forearm

The **principal variations of the ulnar artery in the forearm** are:—(A) It may arise from the brachial above the usual point of division or from the axillary, in which case it usually runs over the flexor muscles, but beneath the fascia, to reach its usual situation in the forearm. The recurrent arteries and the common interosseous are then usually derived from the trunk vessel from which the ulnar is given off. At times it runs beneath the muscles, or merely beneath the skin. (B) It may in some cases of high division of the brachial run beneath the fascia throughout its whole extent in the forearm. (C) In some cases of normal origin from the brachial it takes a superficial course in the forearm, being merely covered by the fascia, the recurrent branches and the common interosseous then arising from the radial.

The **branches of the ulnar artery in the forearm** are:—1. The anterior ulnar recurrent. 2. The posterior ulnar recurrent. 3. The common interosseous: (*a*) volar interosseous—(i) median, (ii) muscular, (iii) medullary, (iv) anterior communicating; (*b*) dorsal interosseous—(i) interosseous recurrent, (ii) muscular, (iii) articular. 4. Muscular. 5. Nutrient. 6. Dorsal ulnar carpal. 7. Volar ulnar carpal.

1. The **anterior ulnar recurrent** is a small branch which leaves the inner side of the ulnar artery soon after its origin, and, running upwards and inwards between the outer edge of the pronator teres and the brachialis, anastomoses in front of the internal epicondyle with the inferior and superior ulnar collaterals. It supplies branches to the muscles between which it runs, and to the skin.

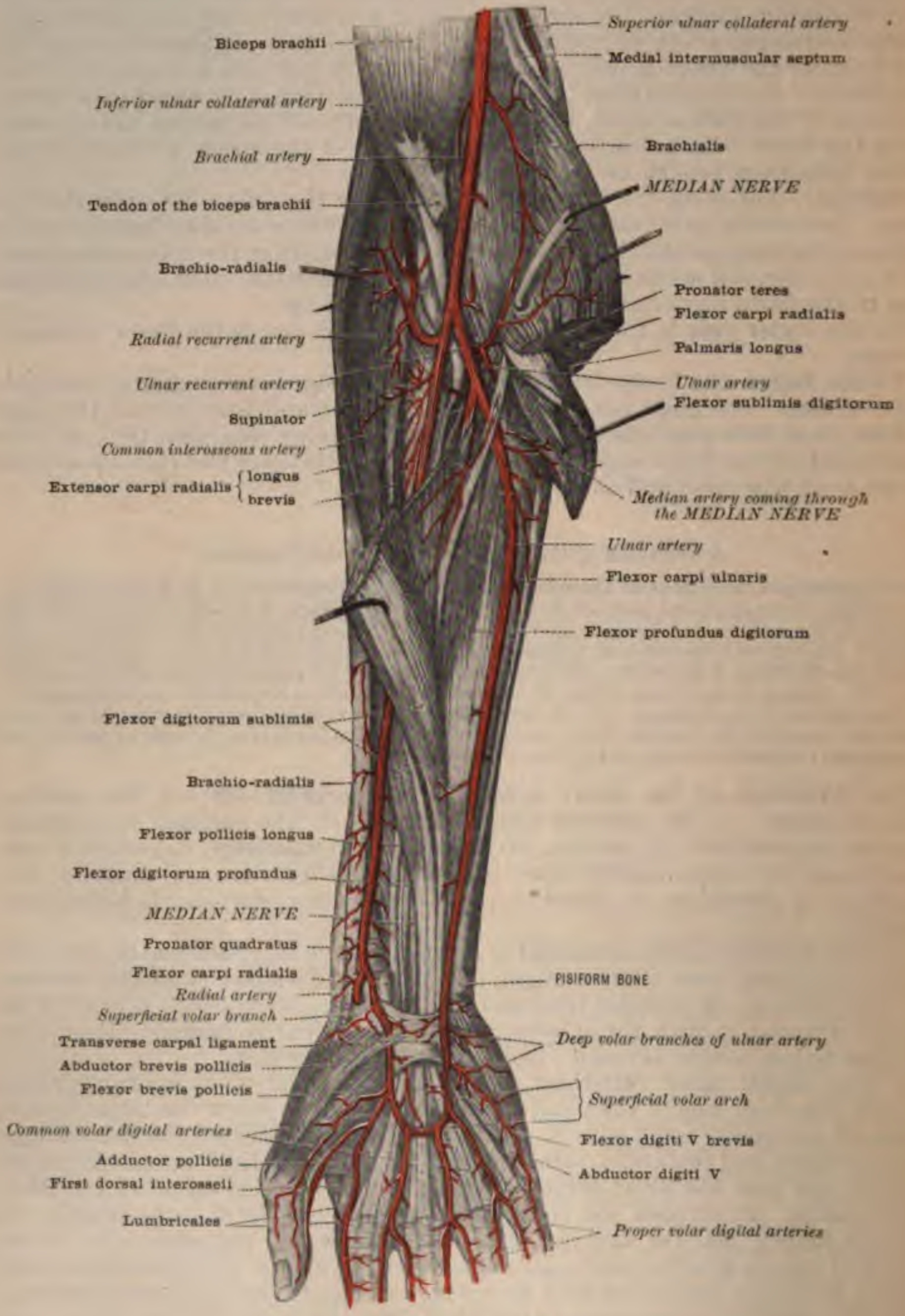
2. The **dorsal ulnar recurrent,** larger than the volar ulnar recurrent, comes off from the inner side of the ulnar artery, either a little below the latter branch, or else as a common trunk with it, and, passing inwards between the flexores digitorum sublimis and profundus, turns upwards to the back of the internal epicondyle, where it lies with the ulnar nerve between the two heads of origin of the flexor carpi ulnaris. It supplies the contiguous muscles—the flexor carpi ulnaris, the palmaris longus, and the flexores digitorum sublimis and profundus—the elbow-joint, and the ulnar nerve, and anastomoses with the inferior and superior ulnar collaterals, and with the interosseous recurrent, forming the so-called rete olecrani.

3. The **common interosseous artery** is a short thick trunk 1·2 cm. (½ in.) or so in length, which comes off from the outer and back part of the ulnar artery about 2·5 cm (1 in.) from its origin, and just before that artery is crossed by the median nerve. It passes backwards and downwards between the flexor pollicis longus and the flexor digitorum profundus, towards the triangular interval bounded by the

upper border of the interosseous membrane, the oblique ligament, and the outer border of the ulna, where it divides into the volar and dorsal interosseous arteries.

(*a*) The **volar interosseous artery,** smaller than the dorsal, but apparently

Fig. 433.—The Volar Arteries of the Forearm and Hand. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

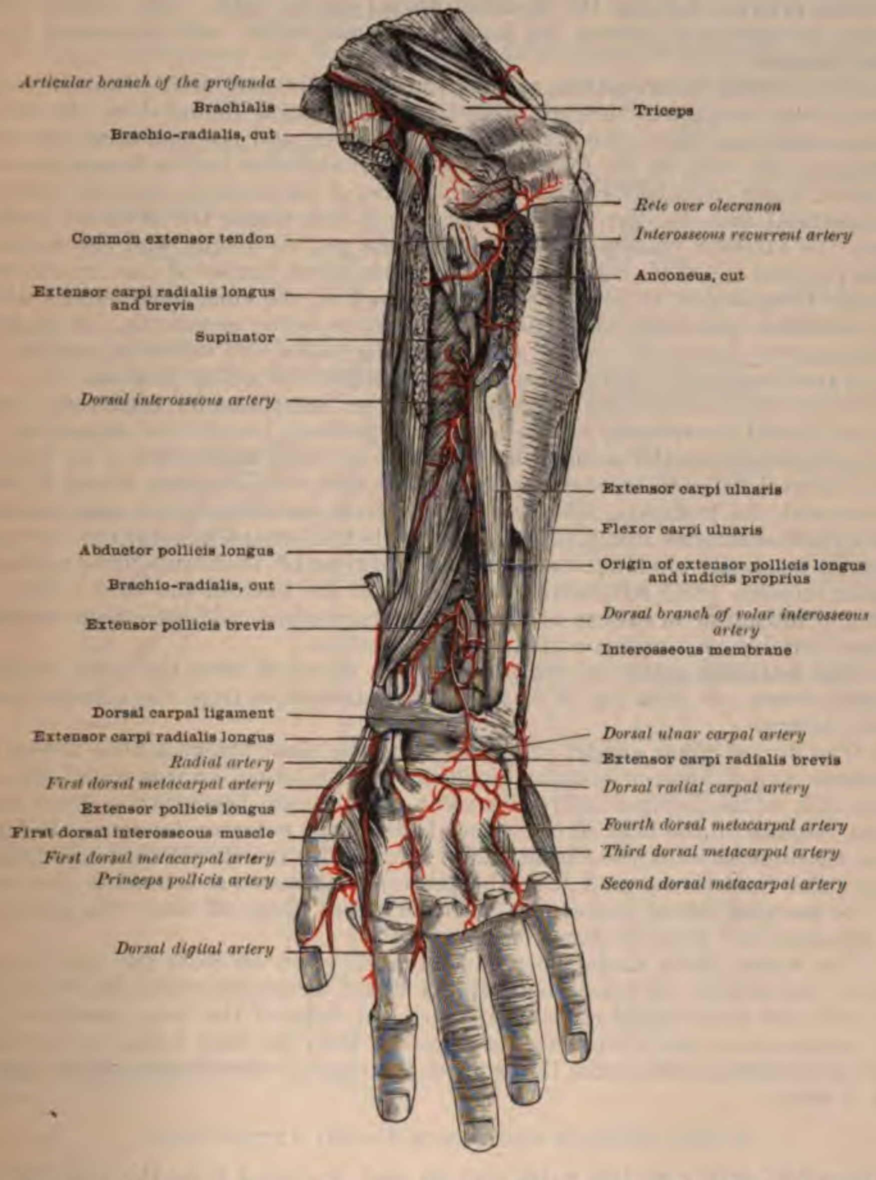

Superior ulnar collateral artery
Medial intermuscular septum
Biceps brachii
Inferior ulnar collateral artery
Brachialis
Brachial artery
MEDIAN NERVE
Tendon of the biceps brachii
Brachio-radialis
Pronator teres
Flexor carpi radialis
Radial recurrent artery
Palmaris longus
Ulnar recurrent artery
Ulnar artery
Flexor sublimis digitorum
Supinator
Common interosseous artery
Extensor carpi radialis { longus brevis
Median artery coming through the MEDIAN NERVE
Ulnar artery
Flexor carpi ulnaris
Flexor profundus digitorum
Flexor digitorum sublimis
Brachio-radialis
Flexor pollicis longus
Flexor digitorum profundus
MEDIAN NERVE
Pronator quadratus
Flexor carpi radialis
PISIFORM BONE
Radial artery
Superficial volar branch
Transverse carpal ligament
Deep volar branches of ulnar artery
Abductor brevis pollicis
Flexor brevis pollicis
Superficial volar arch
Common volar digital arteries
Flexor digiti V brevis
Adductor pollicis
Abductor digiti V
First dorsal interosseii
Lumbricales
Proper volar digital arteries

the direct continuation of the common trunk, courses downwards in front of the interosseous membrane, upon which it lies under cover of the overlapping edges of the flexor digitorum profundus and flexor pollicis longus, to the upper border of the pronator quadratus, where it terminates in two branches, an anterior terminal and a posterior terminal.

The volar interosseous artery is accompanied by two veins and by the deep branch of the median nerve which lies to its radial side. The artery is bound down to the interosseous membrane by aponeurotic fibres.

The **branches of the volar interosseous artery** are:—(1) The **median** artery is a long slender vessel which arises from the volar interosseous immediately after the latter is given off from the common trunk. It passes forwards between the flexor digitorum profundus and the flexor pollicis longus to the median nerve, with which it descends beneath the transverse carpal (anterior annular) ligament into the palm, and when of large size sometimes enters into the formation of the superficial palmar arch. At times the artery arises from the common interosseous before its division. (ii) **Muscular branches** supply the flexor pollicis longus, flexor digi-

FIG. 434.—THE BACK OF THE LEFT FOREARM, WITH THE POSTERIOR INTEROSSEOUS ARTERY AND BRANCHES OF THE RADIAL AT THE BACK OF THE WRIST.
(From a dissection in the Hunterian Museum.)


Articular branch of the profunda
Brachialis
Triceps
Brachio-radialis, cut
Rete over olecranon
Common extensor tendon
Interosseous recurrent artery
Anconeus, cut
Extensor carpi radialis longus and brevis
Supinator
Dorsal interosseous artery
Extensor carpi ulnaris
Flexor carpi ulnaris
Abductor pollicis longus
Origin of extensor pollicis longus and indicis proprius
Brachio-radialis, cut
Dorsal branch of volar interosseous artery
Extensor pollicis brevis
Interosseous membrane
Dorsal carpal ligament
Dorsal ulnar carpal artery
Extensor carpi radialis longus
Extensor carpi radialis brevis
Radial artery
Dorsal radial carpal artery
First dorsal metacarpal artery
Extensor pollicis longus
Fourth dorsal metacarpal artery
First dorsal interosseous muscle
Third dorsal metacarpal artery
First dorsal metacarpal artery
Princeps pollicis artery
Second dorsal metacarpal artery
Dorsal digital artery

torum profundus, pronator quadratus, and the extensor muscles of the thumb, which they reach by passing backwards through the interosseous membrane. (iii) The **nutrient arteries** of the radius and ulna are usually derived from this vessel. (iv) The **anterior terminal** division of the volar interosseous artery passes either in front of or behind the pronator quadratus, but in either case in front of the interosseous membrane, and anastomoses with the volar carpal branches of the radial and ulnar arteries, and with the recurrent branches from the deep palmar arch, forming the so-called **volar carpal rete.** (v) The **dorsal terminal,** the larger division, pierces the interosseous membrane, and continues its course downwards behind the interosseous membrane, under cover of the extensor muscles, to the back of the wrist, where it ends by anastomosing with the dorsal carpal branches of the radial and ulnar arteries, forming the so-called **dorsal carpal rete.** This branch anastomoses, as soon as it pierces the interosseous membrane, with the dorsal interosseous artery.

(*b*) The **dorsal interosseous artery,** the larger division of the common interosseous, turns backwards through the triangular interval bounded by the interosseous membrane below, the oblique ligament above, and the ulna internally, and emerging at the back of the forearm between the abductor pollicis longus and the supinator, under cover of the superficial extensors of the forearm, descends between the superficial and the deep muscles, crossing in this course the abductor pollicis longus, the extensor pollicis brevis, the extensor pollicis longus, and the extensor indicis proprius (fig. 434). It anastomoses at the lower border of this muscle with the volar interosseous, or with the dorsal branch of the volar interosseous which here, as above described, has perforated the interosseous membrane. It is separated from the deep radial nerve at first by the radius and supinator, and on the back of the forearm by the extensores pollicis longus and indicis proprius.

It gives off the following branches:—(i) The **interosseous recurrent** arises from the dorsal interosseous as the latter emerges from beneath the supinator. It runs upwards between the anconeus and supinator, usually under cover of the former, to the interval between the external epicondyle and the olecranon, where it anastomoses with the profunda, inferior ulnar collateral, radial recurrent, and posterior ulnar recurrent arteries, and gives branches to the retiform plexus over the olecranon —the rete olecrani. (ii) **Muscular branches** are given off to the superficial and deep extensor muscles. (iii) **Articular branches** enter the back of the wrist-joint.

4. The **muscular branches of the ulnar artery** supply the contiguous muscles, and are variable in number, origin, and distribution.

5. The **nutrient artery of the ulna** may be given off from the main trunk of the ulnar artery, or from one of its muscular branches, or from the anterior interosseous artery.

6. The **dorsal ulnar carpal** comes off from the ulnar artery a little above the transverse carpal (anterior annular) ligament, and, winding inwards round the end of the ulna or the internal lateral ligament of the wrist, beneath the flexor carpi ulnaris, ramifies on the back of the carpus beneath the extensor tendons. It forms by its anastomosis with the dorsal radial carpal, with the dorsal terminal branch of the volar interosseous and with the posterior interosseous arteries a plexus or rete, the so-called dorsal carpal rete. The branches given off from this plexus or arch are described with the dorsal carpal branch.

7. The **volar ulnar carpal** is a small branch given off from the ulnar artery opposite the carpus. It passes beneath the flexor digitorum profundus to anastomose with the volar radial carpal, with terminal twigs of the volar branch of the volar interosseous, and with recurrent branches from the deep palmar arch, forming an anastomotic arch across the front of the carpus—the so-called **volar carpal arch** or **rete.**

II. Relations of the Ulnar Artery at the Wrist

The **ulnar artery at the wrist** may be said to extend from the upper to the lower border of the transverse carpal (anterior annular) ligament. It here lies immediately to the radial side of the pisiform bone, and to the ulnar side of the hook of the hamate (unciform), the two bones forming for the vessel a protecting channel, which is further converted into a short canal by the expansion of the flexor carpi ulnaris passing from the pisiform to the hook of the hamate (unciform). The ulnar nerve in this situation is immediately to the ulnar side of the artery.

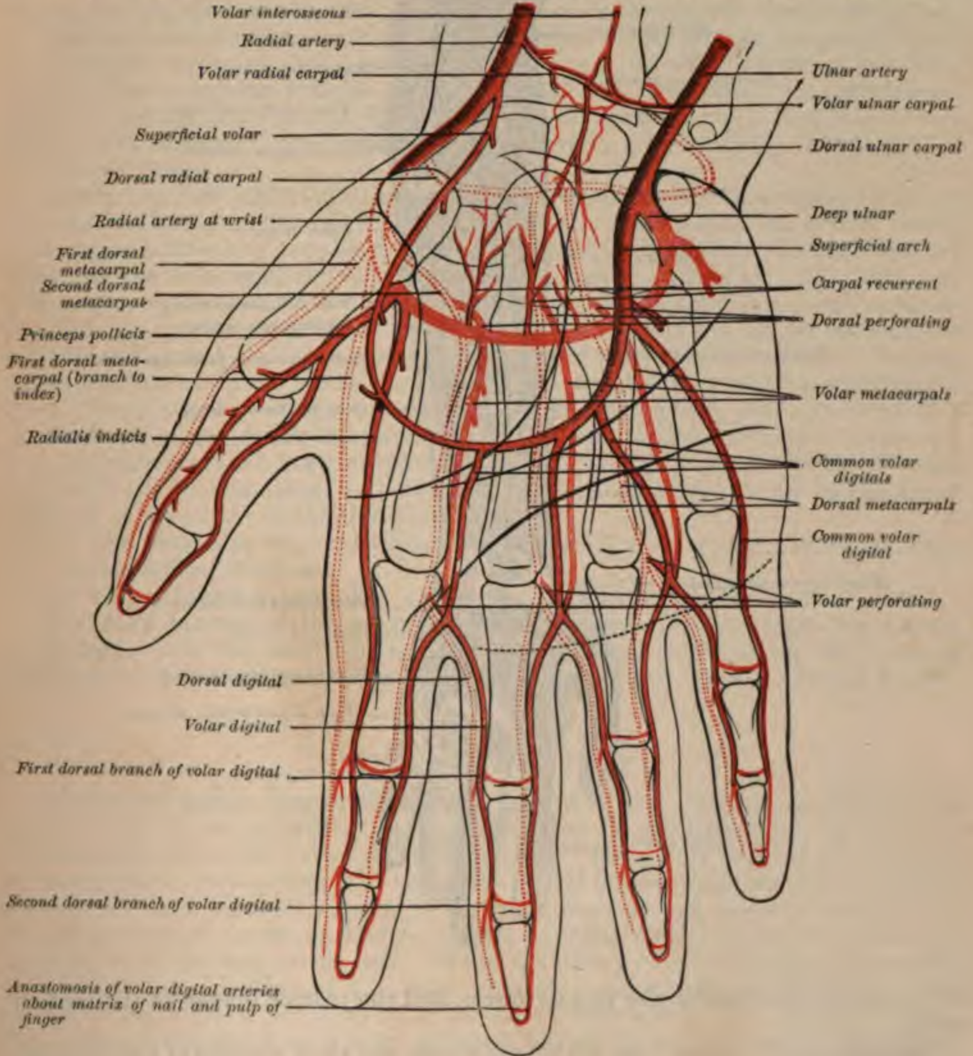
Relations.—**In front** it has, in addition to the expansion above mentioned, the skin and superficial fascia; **below,** it rests on the transverse carpal ligament; **internally** are the ulnar nerve and pisiform bone; **externally,** the hook of the hamate (unciform).

The ulnar artery gives off no named branch in this part of its course.

III. RELATIONS OF THE ULNAR ARTERY IN THE PALM (SUPERFICIAL VOLAR ARCH)

The ulnar artery, on entering the palm, divides into two branches, the superficial and deep.

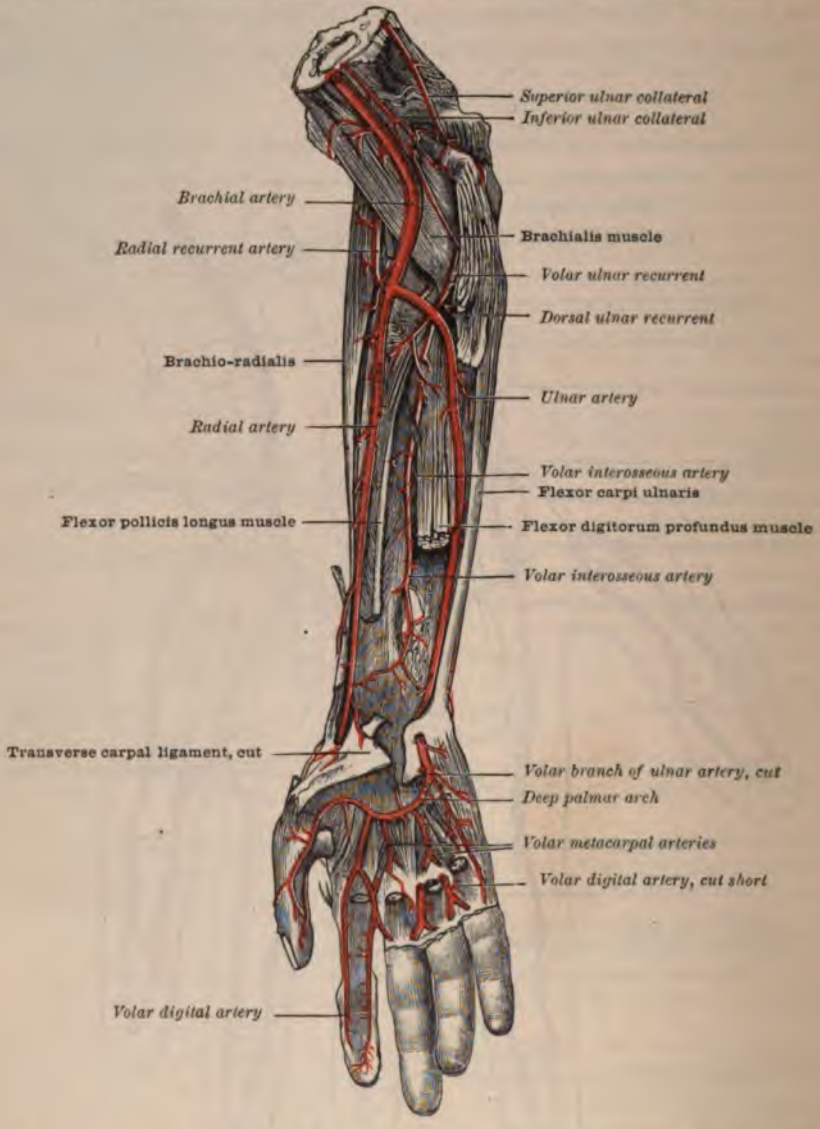
FIG. 435.—ANASTOMOSES AND DISTRIBUTION OF THE ARTERIES OF THE HAND. (Walsham.)


Volar interosseous
Radial artery
Volar radial carpal
Ulnar artery
Volar ulnar carpal
Superficial volar
Dorsal ulnar carpal
Dorsal radial carpal
Deep ulnar
Radial artery at wrist
Superficial arch
First dorsal metacarpal
Second dorsal metacarpal
Carpal recurrent
Dorsal perforating
Princeps pollicis
First dorsal metacarpal (branch to index)
Volar metacarpals
Radialis indicis
Common volar digitals
Dorsal metacarpals
Common volar digital
Volar perforating
Dorsal digital
Volar digital
First dorsal branch of volar digital
Second dorsal branch of volar digital
Anastomosis of volar digital arteries about matrix of nail and pulp of finger

The **superficial branch** (fig. 435), the direct continuation of the vessel, anastomoses with the superficial volar, a branch of the radial, forming what is then known as the **superficial volar arch.** After descending a short distance towards the cleft between the fourth and fifth fingers, it turns outwards towards the thumb, forming a curve with its convexity towards the fingers and its concavity towards the muscles of the thumb, and anastomoses opposite the cleft between the index and middle fingers, at the junction of the upper with the middle third of the palm, with the superficial volar branch of the radial artery to complete the arch. A line drawn across the palm on a level with the thumb at a right angle to the hand will roughly indicate the situation of the arch.

Relations.—In front: in addition to the skin and superficial fascia, the vessel is crossed successively, from within outwards, by the palmaris brevis, the palmar branch of the ulnar nerve, the palmar fascia, and the palmar branch of the median nerve.

FIG. 436.—THE ARTERIES OF THE RIGHT FOREARM AND THE DEEP PALMAR ARCH.


Superior ulnar collateral
Inferior ulnar collateral
Brachial artery
Brachialis muscle
Radial recurrent artery
Volar ulnar recurrent
Dorsal ulnar recurrent
Brachio-radialis
Ulnar artery
Radial artery
Volar interosseous artery
Flexor carpi ulnaris
Flexor pollicis longus muscle
Flexor digitorum profundus muscle
Volar interosseous artery
Transverse carpal ligament, cut
Volar branch of ulnar artery, cut
Deep palmar arch
Volar metacarpal arteries
Volar digital artery, cut short
Volar digital artery

Behind, it rests upon, from within outwards, the short muscles of the little finger, the digital branches of the ulnar nerve, the flexor tendons, and the digital branches of the median nerve.

Variations in the Superficial Palmar Arch

The superficial palmar arch is very subject to variations. (A) It may be formed by the superficial branch of the ulnar anastomosing with the radialis indicis, or with the radial in the palm instead of with the superficial volar branch of the radial. (B) The superficial volar may be larger than usual, and take a greater share than the ulnar in the formation of the arch. (C) The arch may be reinforced by a large median artery, or by an enlarged metacarpal artery. (D) The arch may be double, both the superficial branch of the ulnar and the superficial volar dividing into two branches which anastomose across the palm. (E) The arteries of the thumb and radial side of the index finger may be given off from the arch. (F) The arch may be incomplete, the inner digital branches coming off from the ulnar, and the outer from the superficial volar, the radial in the palm, or an enlarged median artery. (G) The arch may be absent, the digital arteries being then given off from enlarged metacarpal arteries from the deep arch, or from enlarged dorsal metacarpal arteries.

The **branches of the superficial volar arch** are:—(1) The four common digital arteries; (2) the muscular; and (3) the cutaneous.

(1) The **common digital arteries,** usually four in number, are given off from the convexity of the superficial arch and, running downwards through the palm, give off the digital arteries proper to both sides of the little, ring, and middle fingers, and the ulnar side of the index finger. The radial side of the index finger and the thumb are supplied by the first volar metacarpal branch of the radial artery.

The most ulnar of the common digital arteries passes distally over the muscles in the ulnar border of the palm, and thence along the ulnar border of the little finger. The remaining arteries pass distally in the three ulnar intermetacarpal spaces to within about 6 mm. (¼ in.) of the clefts between the fingers, where they divide into branches, the **digital arteries proper,** which supply the sides of contiguous fingers.

As the common digital arteries pass through the palm, they lie between the flexor tendons, on the digital nerves and lumbrical muscles, and beneath the palmar fascia. Just before bifurcating they pass under the superficial transverse ligament, and are joined by the volar metacarpal branches from the deep palmar arch (fig. 435). At this spot they also receive the volar perforating branches from the dorsal metacarpal vessels. On the sides of the fingers the proper digital arteries lie between the palmar and dorsal digital nerves. They anastomose by small branches, forming an arch across the front of the bones on the proximal side of each interphalangeal joint. They supply the flexor tendons and the integuments, and terminate in a plexiform manner beneath the pulp of the finger and around the matrix of the nail. A dorsal digital branch is given off to the back of the fingers about the level of the middle of the first phalanx, and a second but smaller dorsal digital branch about the level of the middle of the second phalanx.

(2) The **muscular branches** from the superficial arch are very small and supply the superficial muscles.

(3) The **cutaneous branches** supply the integuments of the palm.

The **deep branch** of the ulnar artery, also called the communicating artery, sinks deeply into the palm between the abductor and flexor quinti digiti brevis, and joins the radial to form the deep palmar arch. (See The Radial Artery, p. 576.)

THE RADIAL ARTERY

The **radial artery**—the smaller of the two arteries into which the brachial divides at the bend of the elbow—appears as the direct continuation of the brachial. It runs downwards and outwards along the radial side of the forearm as far as the styloid process, then, coiling over the radial lateral ligament and the outer and back part of the wrist, enters the palm of the hand from behind between the first and second metacarpal bones, and ends by anastomosing with the deep branch of the ulnar to form the deep volar arch. Hence the artery is divisible into three parts: that in the forearm, that at the wrist, and that in the palm of the hand. The course of the artery is indicated by a line drawn from a point 2·5 cm. (1 in.) below the centre of the elbow to a point situated 1·2 cm. (½ in.) internal to the styloid process of the radius.

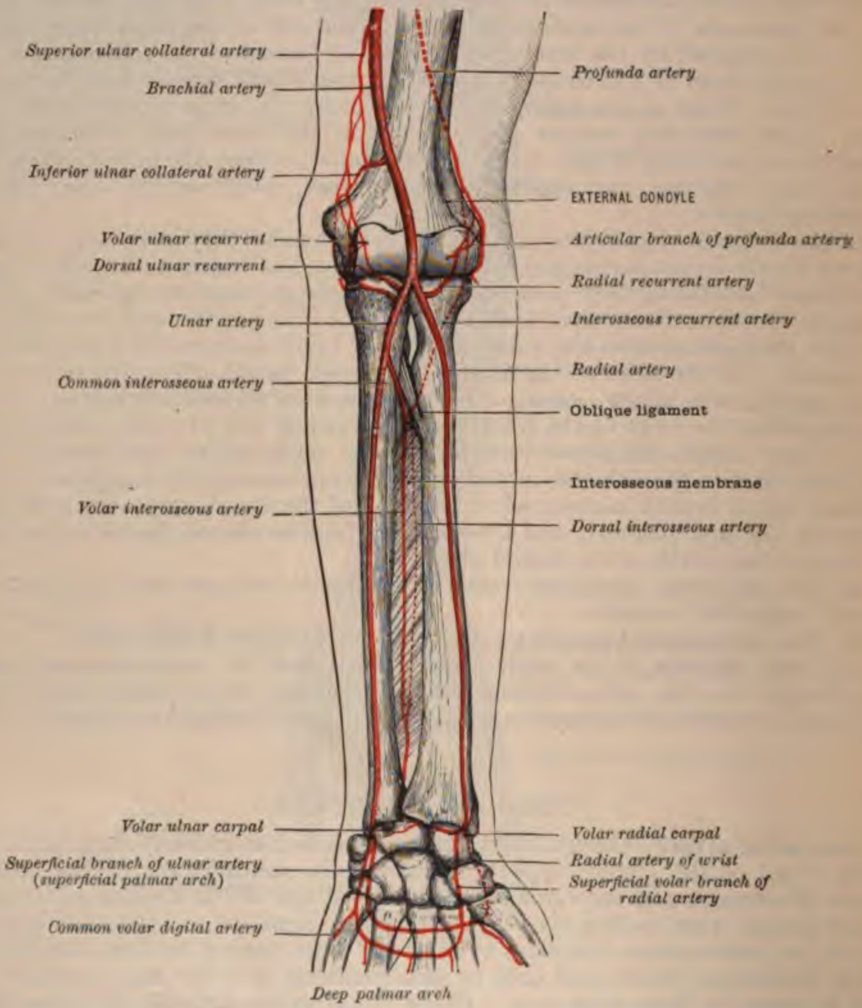
I. The Radial Artery in the Forearm

In its course through the forearm (fig. 433) the radial artery is found in the outermost intermuscular space, and it is only necessary to divide the skin, superficial and deep fascia, to expose the vessel, and in addition in the upper third to separate the brachio-radialis from the pronator teres.

In front, the artery is at first overlapped by the brachio-radialis, but for the rest of its course it is merely covered by the skin, superficial and deep fasciæ, by some cutaneous veins, and by cutaneous branches of the musculo-cutaneous nerve.

Behind, it lies successively from above downwards on the tendon of the biceps, the supinator, from which it is separated by a layer of fat, the insertion of the pronator teres, the radial origin of the flexor digitorum sublimis, the flexor pollicis longus, the pronator quadratus, and the front surface of the lower end of the radius. It is in this last situation, where the artery lies upon the bone and can therefore be easily pressed against it, that the pulse is usually felt.

Fig. 437.—Diagram of the Relation of the Arteries of the Left Forearm to the Bones. (Walsham.)


Superior ulnar collateral artery
Brachial artery
Inferior ulnar collateral artery
Volar ulnar recurrent
Dorsal ulnar recurrent
Ulnar artery
Common interosseous artery
Volar interosseous artery
Volar ulnar carpal
Superficial branch of ulnar artery (superficial palmar arch)
Common volar digital artery
Deep palmar arch
Profunda artery
EXTERNAL CONDYLE
Articular branch of profunda artery
Radial recurrent artery
Interosseous recurrent artery
Radial artery
Oblique ligament
Interosseous membrane
Dorsal interosseous artery
Volar radial carpal
Radial artery of wrist
Superficial volar branch of radial artery

On its **outer side** it has, throughout the whole of its course, the brachio-radialis muscle, the guide to the artery in ligature, and the external vena comes; in its middle third, the superficial radial nerve as well. In its lower third the superficial radial nerve is to its outer side, but separated from it by the brachio-radialis and fascia.

On its **inner side,** in the upper third is the pronator teres, in the lower third the tendon of the flexor carpi radialis, and throughout the whole of its course the internal vena comes.

Variations in the Radial Artery in the Forearm

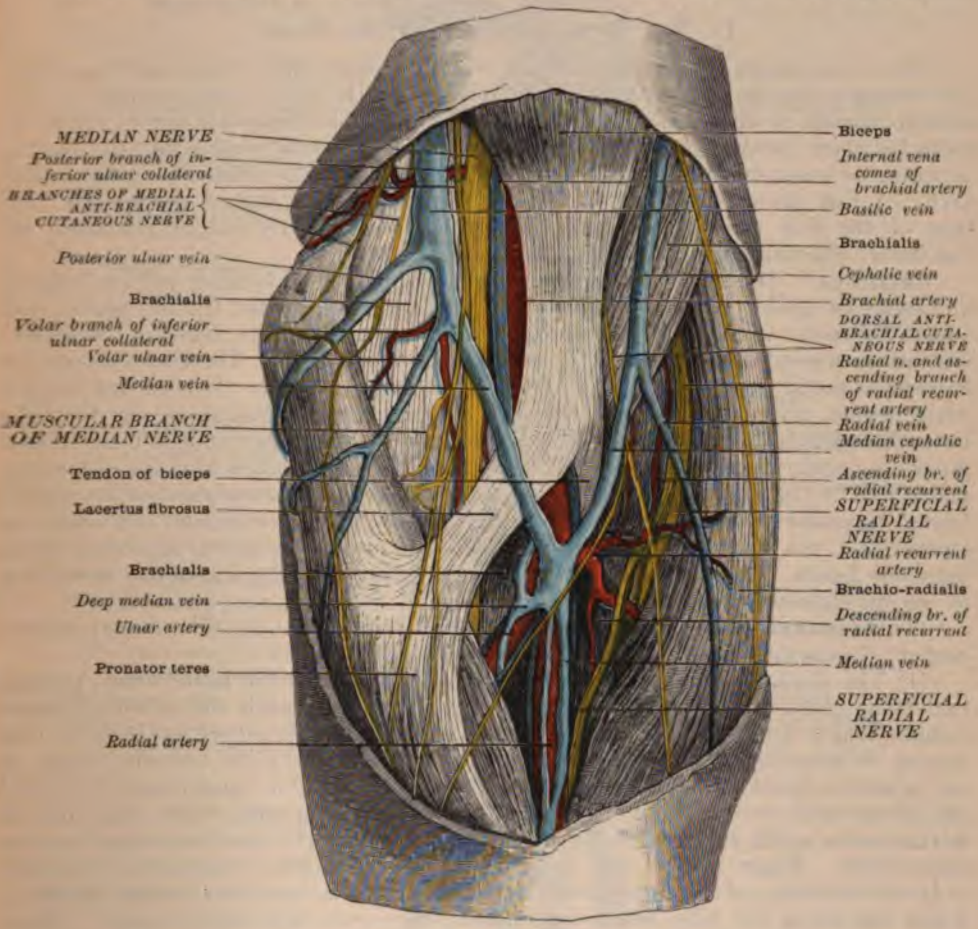
(A) The radial artery may be given off from the brachial higher than usual, or from the axillary artery. (B) It may arise from the brachial lower than the bend of the elbow, but a low division of the brachial is rare. (C) It may run superficial to the fascia of the forearm. (D) It may cross over, instead of under, the extensors of the thumb. (E) It may terminate in the forearm or be absent, its place in the forearm and hand being then supplied by the ulnar, the volar interosseous, or an enlarged median artery. (F) It may be joined by a vas aberrans from the brachial or axillary artery.

The **branches of the radial artery in the forearm** are:—(1) The radial recurrent; (2) the muscular; (3) the volar radial carpal; (4) the superficial volar.

(1) The **radial recurrent** usually arises from the outer side of the radial just below its origin from the brachial. It at first runs outwards on the supinator and then divides into three chief branches (fig. 438). One of these runs transversely outwards through the fibres of the radial (musculo-spiral) nerve, or between the superficial (radial) and deep radial (posterior interosseous) nerves when the radial (musculo-spiral) divides higher than usual, into the brachio-radialis and extensor carpi radialis longus and brevis, and anastomoses with the interosseous recurrent. **A second** ascends between the brachialis and brachio-radialis, with the radial (musculo-spiral) nerve, and anastomoses with the profunda artery. A **third** descends with the superficial radial nerve under cover of the brachio-radialis, supplying that muscle. The radial recurrent also gives off branches to the elbow-joint.

Fig. 438.—The Bend of the Elbow, Left Side.

(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)


MEDIAN NERVE
Posterior branch of inferior ulnar collateral
BRANCHES OF MEDIAL ANTI-BRACHIAL CUTANEOUS NERVE
Posterior ulnar vein
Brachialis
Volar branch of inferior ulnar collateral
Volar ulnar vein
Median vein
MUSCULAR BRANCH OF MEDIAN NERVE
Tendon of biceps
Lacertus fibrosus
Brachialis
Deep median vein
Ulnar artery
Pronator teres
Radial artery
Biceps
Internal vena comes of brachial artery
Basilic vein
Brachialis
Cephalic vein
Brachial artery
DORSAL ANTI-BRACHIAL CUTANEOUS NERVE
Radial n. and ascending branch of radial recurrent artery
Radial vein
Median cephalic vein
Ascending br. of radial recurrent
SUPERFICIAL RADIAL NERVE
Radial recurrent artery
Brachio-radialis
Descending br. of radial recurrent
Median vein
SUPERFICIAL RADIAL NERVE

(2) The **muscular branches of the radial artery** come off irregularly to supply the contiguous muscles on the outer side of the forearm.

(3) The **volar radial carpal** arises from the inner side of the radial artery about the level of the lower border of the pronator quadratus. It crosses the front of the radius beneath the flexor muscles, and anastomoses with the volar carpal

branch of the ulnar, forming what is sometimes called the volar carpal arch, or what is, more properly speaking, an arterial plexus or rete—the volar carpal rete. This plexus is joined above by small twigs from the volar metacarpal arteries, and below by recurrent branches from the deep volar arch. It supplies branches to the lower end of the radius, and to the wrist and carpal joints.

(4) The **superficial volar** leaves the radial artery as the latter vessel is about to turn over the radial lateral ligament to the back of the wrist. It courses forwards over the short muscles of the ball of the thumb, and anastomoses with the superficial branch of the ulnar artery to complete the superficial volar arch. It supplies small branches to the muscles of the ball of the thumb, and at times terminates in these muscles without joining the arch. Occasionally it passes beneath the abductor pollicis brevis. This branch is often small and ends in the muscles of the thumb.

II. The Radial Artery at the Wrist

The radial artery at the wrist winds over the outer side of the carpus, under the extensor tendons of the thumb, from a spot a little below and internal to the styloid process of the radius to the base of the first interosseous space, where it sinks between the two heads of the first dorsal interosseous muscle into the palm, to form, by anastomosing with the deep branch of the ulnar artery, the deep volar arch. A line drawn from 1·2 cm. (½ in.) internal to the styloid process to the base of the first interosseous space, which can be distinctly felt on the back of the hand, will roughly indicate the course of the artery.

Relations.—The artery is covered successively by the abductor pollicis longus and extensor pollicis brevis, by branches of the superficial radial (radial) nerve and superficial radial veins, and, just before it sinks between the two heads of the interosseous muscle, by the tendon of the extensor pollicis longus. The branches of the superficial radial nerve to the thumb and index finger cross it. It is at first somewhat deeply placed beneath the first-mentioned extensor muscles of the thumb; but subsequently it lies quite superficial, and can be felt pulsating in a little triangular depression bounded on either side by the extensores pollicis longus and brevis, and above by the lower end of the radius. The artery lies successively on the radial lateral ligament of the wrist, on the navicular (scaphoid), the greater multangular (trapezium), the base of the first metacarpal bone, and on the dorsal ligaments uniting these bones. It has usually with it two companion veins, and a few branches of the musculo-cutaneous nerve.

The **branches of the radial artery at the wrist** are:—(1) The dorsal radial carpal; (2) the first dorsal metacarpal.

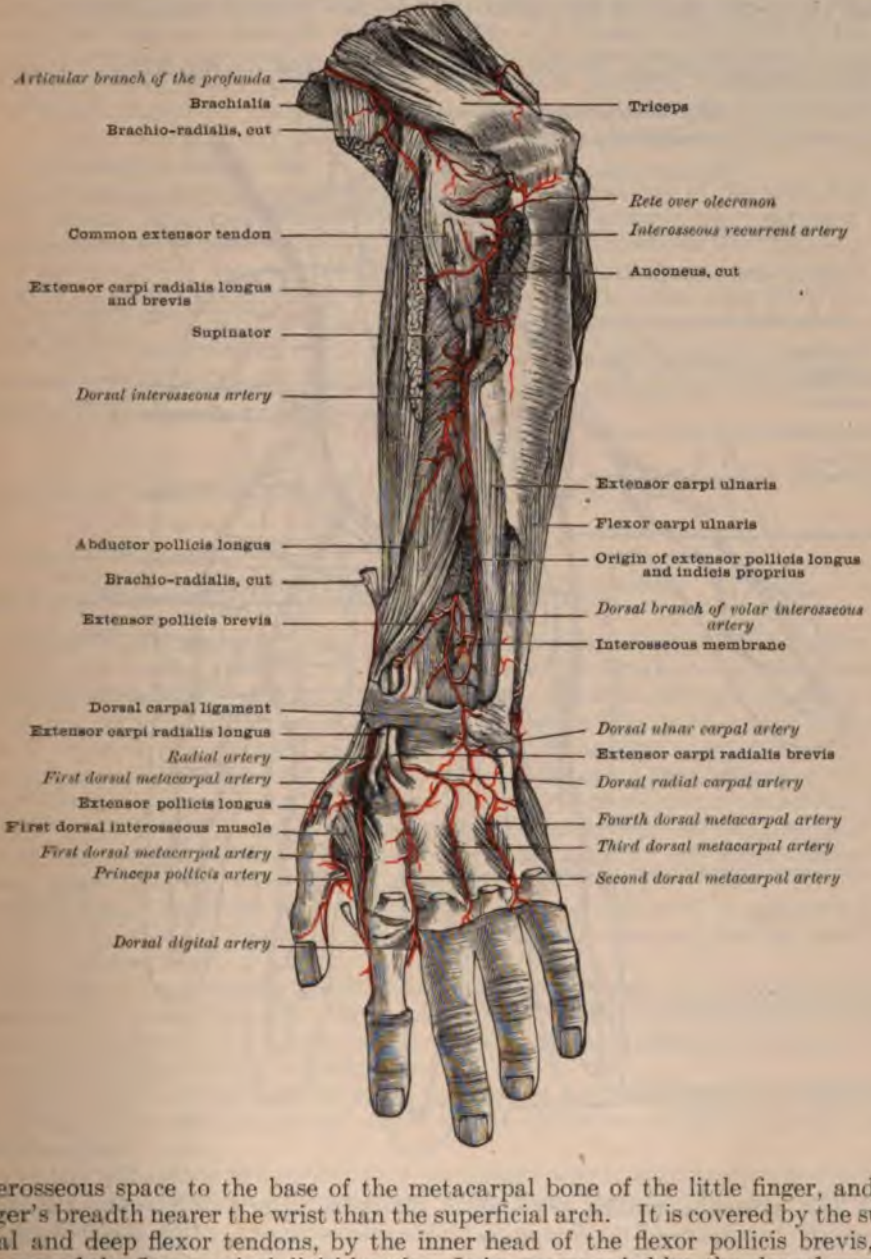
(1) The **dorsal radial carpal** arises from the radial as the latter vessel passes under the abductor pollicis longus, and runs inwards beneath the extensor carpi radialis longus and brevis, and the extensor pollicis longus, across the back of the carpus, to anastomose with the dorsal ulnar carpal and with the terminal twigs of the posterior branch of the volar interosseous artery. This anastomosis is called the dorsal carpal rete. From this rete are given off the second, third, and fourth **dorsal metacarpal arteries** to the second, third, and fourth intermetacarpal spaces respectively. These vessels run downwards on the dorsal interosseous muscles as far as the flexure of the fingers, and there divide into two branches (**dorsal digital**), which run along the sides of the contiguous fingers on their dorsal aspect. Near their proximal ends they anastomose with the dorsal perforating branches of the deep volar arch. Distally they are connected by volar perforating branches with the digital arteries of the corresponding spaces. The branches which run along the backs of the fingers anastomose with the dorsal branches of the first dorsal digital arteries derived from the volar common digital vessels (fig. 439).

(2) The **first dorsal metacarpal** (fig. 435, 439) is given off by the radial shortly before it passes between the two heads of the first dorsal interosseous muscle. It quickly divides into two branches which supply the dorsal surface of the thumb and the radial side of the index finger towards its dorsal surface.

III. The Radial Artery in the Palm (the Deep Volar Arch)

The **radial artery** enters the palm between the first and second metacarpal bones at the base of the first interosseous space, by passing between the two heads of the first dorsal interosseous muscle. It then runs inwards between the abductor pollicis and inner head of the flexor pollicis brevis, and continuing its course in a slight curve with the convexity forwards, across the base of the metacarpal bones and interosseous muscles, it anastomoses with the deep branch of the ulnar, forming the deep volar arch. The arch thus formed may be said to extend from the first interosseous space to the base of the metacarpal bone of the little finger, and is a finger's breadth nearer the wrist than the superficial arch. It is covered by the superficial and deep flexor tendons, by the inner head of the flexor pollicis brevis, and by part of the flexor quinti digiti brevis. It is accompanied by the deep branch of the ulnar nerve, and two small venæ comites.

FIG. 439.—THE RADIAL ARTERY AT THE WRIST, LEFT FOREARM. (From a dissection in the Hunterian Museum.)

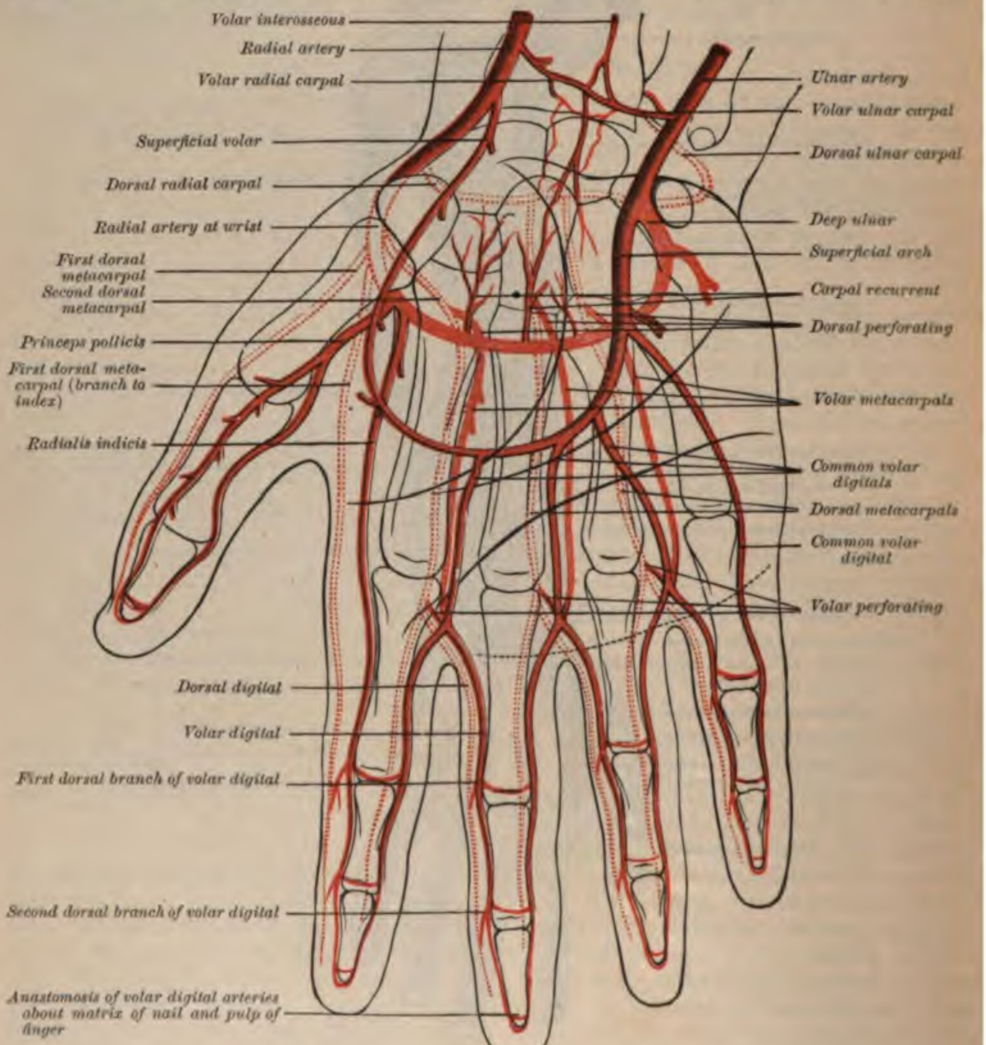

Articular branch of the profunda
Brachialis
Brachio-radialis, cut
Common extensor tendon
Extensor carpi radialis longus and brevis
Supinator
Dorsal interosseous artery
Abductor pollicis longus
Brachio-radialis, cut
Extensor pollicis brevis
Dorsal carpal ligament
Extensor carpi radialis longus
Radial artery
First dorsal metacarpal artery
Extensor pollicis longus
First dorsal interosseous muscle
First dorsal metacarpal artery
Princeps pollicis artery
Dorsal digital artery
Triceps
Rete over olecranon
Interosseous recurrent artery
Anconeus, cut
Extensor carpi ulnaris
Flexor carpi ulnaris
Origin of extensor pollicis longus and indicis proprius
Dorsal branch of volar interosseous artery
Interosseous membrane
Dorsal ulnar carpal artery
Extensor carpi radialis brevis
Dorsal radial carpal artery
Fourth dorsal metacarpal artery
Third dorsal metacarpal artery
Second dorsal metacarpal artery

Variations in the Deep Volar Arch

(A) The deep volar arch may be larger than usual, and its metacarpal branches supply the place of one or more of the common digital arteries by dividing at the cleft of the fingers into digital branches. (B) It may be reinforced by enlarged posterior perforating branches from the radial and its branches on the back of the hand, or by a large volar interosseous. (C) The radial may join the deep arch by passing through the second instead of the first interosseous space. (D) The princeps pollicis and radialis indicis may come off from the superficial arch or from the superficial volar, or from a separate branch of the radial which passes through the first interosseous space.

The **branches of the deep volar arch** are:—(1) The princeps pollicis; (2) the radialis indicis; (3) the volar metacarpals (three in number); (4) the recurrent carpal; (5) the posterior perforating. The first two are usually spoken of as coming off from the radial artery in the palm; the last three from the deep palmar arch.

Fig. 440.—Anastomoses and Distribution of the Arteries of the Hand. (Walsham.)


Volar interosseous
Radial artery
Volar radial carpal
Superficial volar
Dorsal radial carpal
Radial artery at wrist
First dorsal metacarpal
Second dorsal metacarpal
Princeps pollicis
First dorsal metacarpal (branch to index)
Radialis indicis
Ulnar artery
Volar ulnar carpal
Dorsal ulnar carpal
Deep ulnar
Superficial arch
Carpal recurrent
Dorsal perforating
Volar metacarpals
Common volar digitals
Dorsal metacarpals
Common volar digital
Volar perforating
Dorsal digital
Volar digital
First dorsal branch of volar digital
Second dorsal branch of volar digital
Anastomosis of volar digital arteries about matrix of nail and pulp of finger

(1) The **princeps pollicis** arises from the radial artery as it enters the palm between the two heads of the first dorsal interosseous muscle. It passes downward between the adductor pollicis transversus and the first dorsal interosseous muscle parallel to the metacarpal bone, and between the two portions of the flexor pollic brevis under cover of the flexor pollicis longus. Opposite the metacarpo-phalange joint it usually divides into two branches, one of which is distributed to each si of the thumb on its palmar aspect. These vessels anastomose with each other at t end of the thumb, like the other digital arteries.

(2) The **radialis indicis** comes off from the radial artery a little lower th

the former vessel, or as a common trunk with it, and passes forwards between the first dorsal interosseous and adductor pollicis transversus, parallel to the radial side of the second metacarpal bone. After emerging from beneath the adductor pollicis transversus it continues its course along the radial side of the index finger, on its palmar aspect, as far as the tip, anastomosing in this course with the digital artery on the opposite side of the finger in a way similar to that of the other digital arteries. It frequently communicates, at the lower border of the adductor pollicis, with the superficial volar arch and princeps pollicis. It gives off a dorsal branch, which anastomoses with the branch from the first dorsal metacarpal to the index finger.

(3) The **volar metacarpal arteries,** three in number, come off from the convexity of the deep arch, and, coursing downwards in the centre of the second, third, and fourth interosseous spaces on the interosseous muscles, terminate near the clefts of the fingers by anastomosing with the digital arteries from the superficial arch. These vessels supply the interosseous muscles and the bones, and the second, third, and fourth lumbricales.

(4) The **recurrent branches** come off from the concavity of the arch, and consist of two or three small vessels which run upwards towards the wrist, and anastomose above with the volar branch of the volar interosseous, and laterally with the volar radial and ulnar carpal arteries, forming the so-called anterior carpal rete.

(5) The **dorsal perforating,** also usually three in number, pass from the arch directly through the second, third, and fourth interosseous spaces between the two heads of the corresponding dorsal interosseous muscle, and join the proximal ends of the first dorsal interosseous, and the second, third, and fourth dorsal metacarpal arteries respectively.

THE DESCENDING, OR THORACIC AORTA

The **thoracic aorta** (fig. 441) extends from the termination of the aortic arch at the lower border of the body of the fifth thoracic vertebra to the lower border of the body of the twelfth thoracic vertebra, where it passes through the aortic opening in the diaphragm, and is thence continued under the name of the abdominal aorta. It is at first situated a little to the left of the vertebral column, but as it descends, approaches the front of the column, at the same time following the backward curve of the spine, and at its passage through the diaphragm is almost in the middle line. It lies in the posterior mediastinum, having the œsophagus at first a little to the right of it, then in front of it, and just above the tenth thoracic vertebra, where this tube pierces the diaphragm, a little to its left side.

Relations.—In front it is crossed from above downwards by the root of the left lung, by the œsophagus, which separates it from the pericardium and heart, and by the diaphragm.

Behind, it lies upon the lower seven thoracic vertebræ, and is crossed obliquely opposite the seventh or eighth thoracic vertebra by the vena hemiazygos (azygos minor) and opposite the fifth or sixth vertebra by the accessory hemiazygos vein, or by one or more of the left intercostal veins.

On the **right side** it has, above, the œsophagus, and lower down the right pleura and lung. The vena azygos and thoracic duct also lie to the right, but on a somewhat posterior plane.

On the **left side** it has the left lung and pleura above, and the œsophagus below. The vena hemiazygos and the accessory hemiazygos vein are also to the left, but on a posterior plane.

BRANCHES OF THE THORACIC AORTA

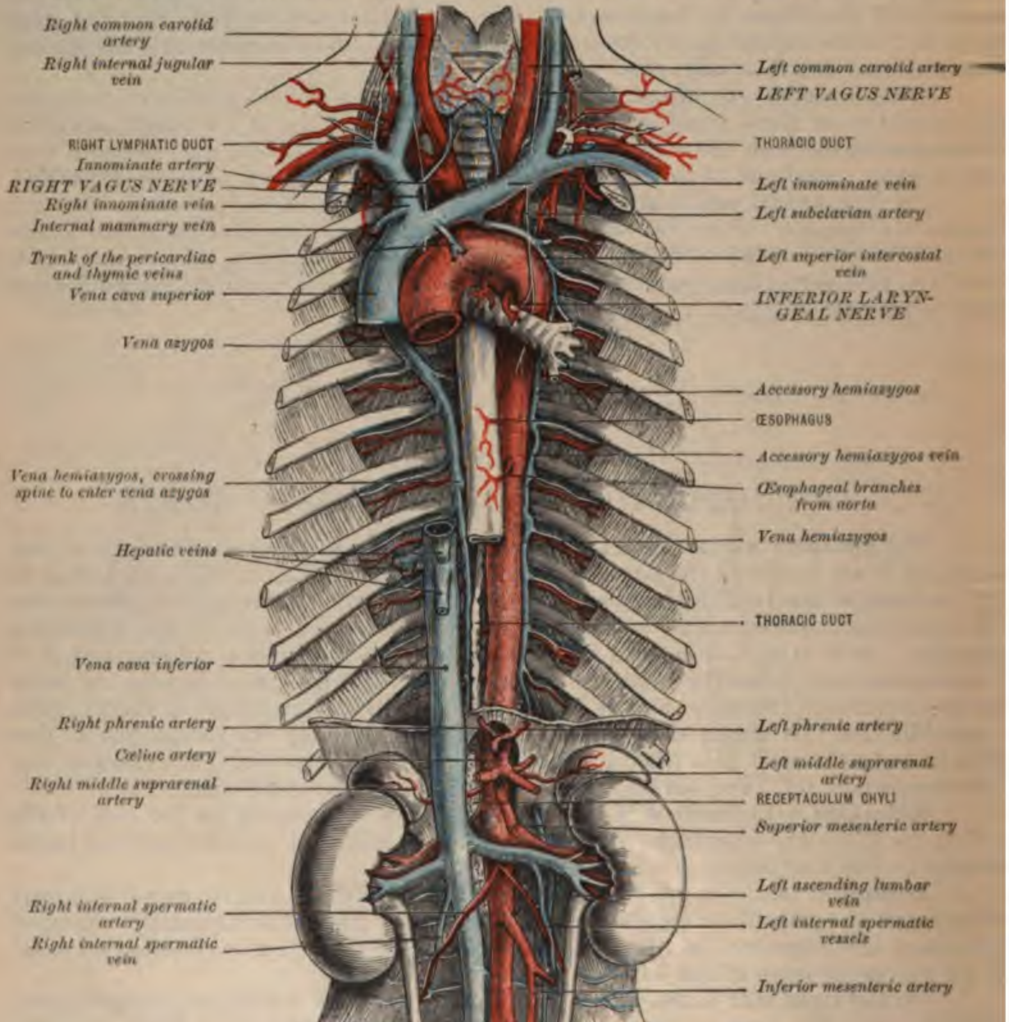
The **branches of the thoracic aorta** may be divided into the visceral and the parietal. The **visceral** are:—(1) The pericardiac; (2) the bronchial; and (3) the œsophageal. The **parietal** are:—(1) The intercostal; (2) the superior phrenic; and (3) the arteria aberrans.

A. Visceral Branches

(1) The **pericardiac**—two or three small branches, irregular in their origin, course, and distribution—pass to the posterior surface of the pericardium to supply that structure, and anastomose with the other pericardiac branches. They give small twigs to the posterior mediastinal glands.

(2) The **bronchial arteries** supply the bronchi and the lung substance. They vary considerably in their origin, course, and distribution; they are usually three in number—one on the right side, and two on the left.

Fig. 441.—The Arch of the Aorta, the Thoracic Aorta, and the Abdominal Aorta, with the Superior and Inferior Vena Cava and the Innominate and Azygos Veins.


Right common carotid artery
Right internal jugular vein
RIGHT LYMPHATIC DUCT
Innominate artery
RIGHT VAGUS NERVE
Right innominate vein
Internal mammary vein
Trunk of the pericardiac and thymic veins
Vena cava superior
Vena azygos
Vena hemiazygos, crossing spine to enter vena azygos
Hepatic veins
Vena cava inferior
Right phrenic artery
Cœliac artery
Right middle suprarenal artery
Right internal spermatic artery
Right internal spermatic vein
Left common carotid artery
LEFT VAGUS NERVE
THORACIC DUCT
Left innominate vein
Left subclavian artery
Left superior intercostal vein
INFERIOR LARYNGEAL NERVE
Accessory hemiazygos
ŒSOPHAGUS
Accessory hemiazygos vein
Œsophageal branches from aorta
Vena hemiazygos
THORACIC DUCT
Left phrenic artery
Left middle suprarenal artery
RECEPTACULUM CHYLI
Superior mesenteric artery
Left ascending lumbar vein
Left internal spermatic vessels
Inferior mesenteric artery

(*a*) The **right bronchial** generally arises either from the first right aortic intercostal, or else as a common trunk with the left upper bronchial from the front o the thoracic aorta just below the level of the bifurcation of the trachea. It passe outwards on the back of the right bronchus, and is distributed to the bronchi an lung substance. (*b*) The **left upper bronchial** arises from the front of the th racic aorta just below the bifurcation of the trachea, or as a common trunk wi the right bronchial. (*c*) The **left lower bronchial** arises from the front of the th racic aorta just below the level of the left bronchus. Like the corresponding artery on the right side, the left bronchial arteries run outwards on the left bronchus, and, after dividing and subdividing on the back of the bronchi, supply the bronchi themselves and the lung substance. Small twigs are given off from the bronchial arteries to the bronchial glands and to the œsophagus.

(3) The **œsophageal arteries,** four or sometimes five in number, arise at intervals from the front of the thoracic aorta, the first coming off just below the left lower bronchial. They usually increase in size from above downwards, the upper coming off more towards the right side of the aorta, the lower more towards the left side. They pass forwards to the œsophagus, supplying that tube and anastomosing with each other and with the descending œsophageal branches of the inferior thyreoid above, and with the ascending œsophageal branches of the phrenic and gastric arteries below, thus forming a chain of anastomoses along the whole length of the tube.

B. Parietal Branches

(1) The **aortic intercostal arteries,** usually eleven or ten in number on each side, supply the lower intercostal spaces, the one or two upper spaces being supplied by the superior intercostal branch of the subclavian artery. The lowest artery runs along the lower border of the last rib, and is sometimes called the **subcostal artery;** it is similar in its distribution to the other intercostals.

The aortic intercostals arise in pairs from the back part of the thoracic aorta, and at once turning, the one to the right, the other to the left, wind backwards over the front and sides of the vertebral bodies to reach the intercostal spaces, which they follow, and anastomose in front with the anterior intercostals given off from the internal mammary and musculo-phrenic arteries respectively. In fœtal life these arteries run almost transversely backwards, or even with a slight inclination downwards, to the intercostal spaces; but after the first year, in consequence of the disproportionate growth of the aorta and vertebral column, the upper intercostals have to ascend to reach their respective spaces. For convenience of description the intercostal arteries may be divided into two portions—the vertebral, which lies upon the bodies of the vertebræ; and the intercostal, which lies in the intercostal spaces.

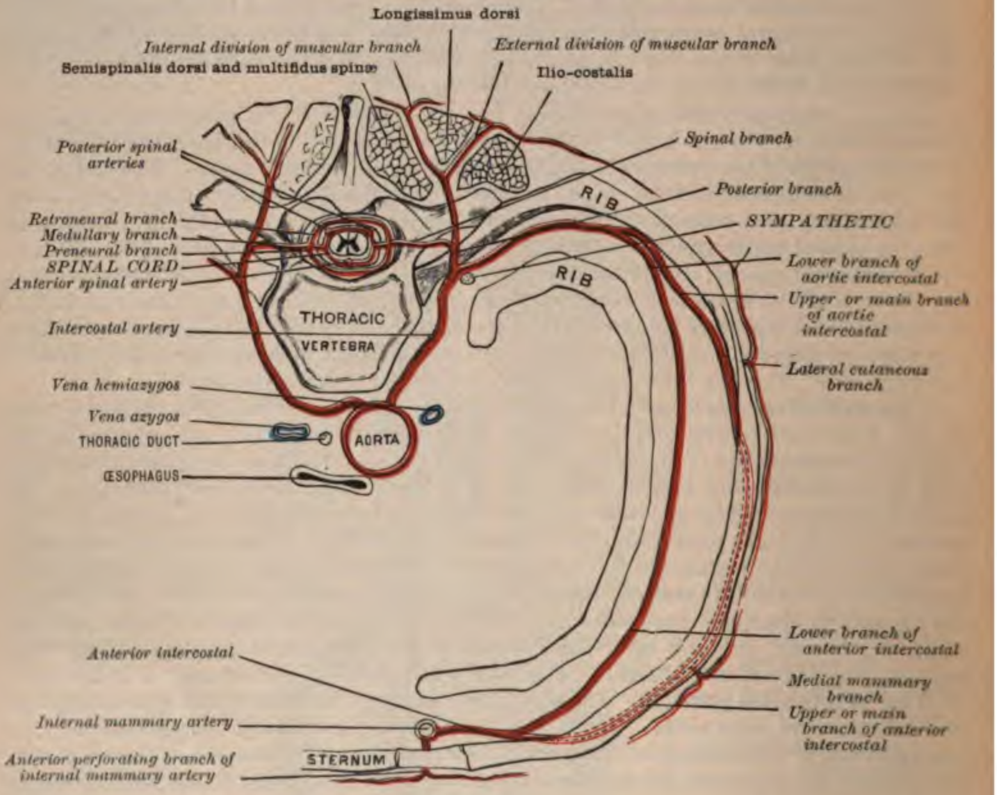
The vertebral portion.—The arteries in their course around the vertebræ differ on the two sides of the body. On the **right side** the arteries—and especially the upper, in consequence of the aorta lying a little to the left side of the spine in the upper part of its course—are longer than the left. They wind over the front and right side of the vertebræ, being crossed by the thoracic duct and vena azygos (major), and covered by the right pleura and lung. The upper are also crossed by the œsophagus. They give off small branches to the bodies of the vertebræ and anterior longitudinal ligament. On the **left side,** as the intercostals wind around the sides of the bodies of the vertebræ, the lower are crossed by the vena hemiazygos (azygos minor), the two upper by the left superior intercostal vein, and the two next by the accessory hemiazygos vein when this is present. They are all covered by the left pleura and lung.

The intercostal portion.—In their course through the intercostal spaces the arteries are alike on both sides. They at first cross the intercostal spaces obliquely, in consequence of the downward direction of the ribs, towards the angle of the rib above, and thence are continued forward in the costal groove, and anastomose with the superior branches of the anterior intercostals from the internal mammary in the upper spaces, and from the musculo-phrenic in the lower spaces. They lie at first on the external intercostal muscles, being covered in front by the pleura and lung, the endothoracic fascia, and the subcostal muscles. Opposite the heads of the ribs they are crossed by the sympathetic nerve. At the angle of the ribs they pass under cover of the internal intercost[illegible]uscles, and thence to their termination lie between the two intercostal muscles[illegible]eir situation in the midspace as far as the angle of the rib should be remembered in performing paracentesis thoracis. To avoid the risk of injuring the vessels, the puncture should not be made further back than the angle of the ribs. They are accompanied by an intercostal nerve and vein, the vein lying above and the nerve below, except in the upper spaces, where the artery, having to ascend to reach the space, at first lies below the nerve which passes transversely outwards. The uppermost aortic intercostal artery anastomoses with the superior intercostal from the subclavian, and at times supplies almost entirely the second intercostal space. The arteries to the tenth and eleventh spaces on reaching the end of their respective ribs pass between the abdominal muscles, and anastomose with the deep epigastric artery from the external iliac, and with the lumbar arteries from the abdominal aorta. The artery beneath the twelfth rib anastomoses with the lumbar arteries and with the external circumflex iliac.

The intercostal arteries give off the following branches:—

(*a*) **The posterior branch.**—This large branch is given off from the intercostals opposite the quadrilateral space bounded by the transverse process of the vertebra above, the neck of the rib below, the body of the vertebra internally, and the anterior costo-transverse ligament externally. Passing backwards towards this space with the dorsal branch of the corresponding intercostal nerve, the dorsal branch divides opposite the intervertebral foramen into a spinal and a muscular branch. (i) The **spinal branch** enters the intervertebral foramen along with the undivided trunk of the intercostal nerve, and subdivides into three branches:—(*a*) an anterior, or preneural, which ramifies on the back of the body of the vertebra and anastomoses with the corresponding vessels above and below; (*β*) a posterior, or retroneural, which ramifies over the back of the spinal canal and also anastomoses with the like artery above and below; and (*γ*) a middle or medullary, which, passing inwards in the sheath of dura mater to the spinal cord, anastomoses with the anterior spinal artery in front, and with the posterior spi[illegible]rtery behind. (ii) The **muscular branch** passes backwards through the qu[illegible]ateral space, and soon subdivides into an external and internal branch. The former passes between the longissimus dorsi and ilio-costalis, and, after supplying these muscles, gives off **medial cutaneous branches.** The latter or internal branch pierces the multifidus spinæ, and, emerging between the longissimus dorsi and semispinalis dorsi near the spinous processes, gives off **lateral cutaneous branches.** It supplies the muscles in its course.

FIG. 442.—SCHEME OF INTERCOSTAL ARTERY. (Walsham.)


Longissimus dorsi
Internal division of muscular branch
External division of muscular branch
Semispinalis dorsi and multifidus spinæ
Ilio-costalis
Posterior spinal arteries
Spinal branch
RIB
Posterior branch
SYMPATHETIC
Retroneural branch
Medullary branch
Preneural branch
SPINAL CORD
Anterior spinal artery
RIB
Lower branch of aortic intercostal
Upper or main branch of aortic intercostal
THORACIC
VERTEBRA
Intercostal artery
Lateral cutaneous branch
Vena hemiazygos
Vena azygos
THORACIC DUCT
AORTA
ŒSOPHAGUS
Anterior intercostal
Lower branch of anterior intercostal
Medial mammary branch
Internal mammary artery
Upper or main branch of anterior intercostal
Anterior perforating branch of internal mammary artery
STERNUM

(*b*) The **collateral intercostal branch** comes off from the intercostal artery near the angle of the rib above, and descends to the upper border of the rib below, along which it runs between the intercostal muscles to anastomose with the inferi division of the anterior intercostal branch of the internal mammary artery. It is much smaller than the main intercostal artery, and helps to supply the structures in the intercostal space and neighbouring parts.

(*c*) The **pleural branches** ramify beneath the pleura, forming a plexus by anastomosing with like branches above and below.

(*d*) The **muscular branches** supply the intercostals, serratus anterior, and pectoralis major and minor, and anastomose with the long and short thoracic branches of the axillary artery.

(*e*) The **lateral cutaneous branches,** both pectoral and abdominal, run with the lateral cutaneous branches of the intercostal nerves to the skin. They have both **anterior** and **posterior branches.**

(*f*) The **mammary branches** are given off from the intercostal arteries in the third, fourth, and fifth intercostal spaces, and supply the mammary gland. They are of large size during lactation, and generally require a ligature in the removal of the breast. They are in two groups, **medial** and **lateral.**

(2) The **superior phrenic branches** are small twigs coming off from the thoracic aorta immediately above the diaphragm. They are distributed to the vertebral portion of the diaphragm on its upper surface.

(3) The **aberrant artery** is a small twig which, arising from the thoracic aorta near the right bronchial artery, passes upwards and to the right behind the œsophagus and trachea, and is occasionally found to anastomose on the œsophagus with the arteria aberrans of the superior intercostal artery (see p. 555). It is regarded as the remains of the right aortic dorsal stem (fig. 403).

THE ABDOMINAL AORTA

The **abdominal aorta** (fig. 443), the continuation of the descending or thoracic aorta, begins at the aortic opening in the diaphragm opposite the lower border of the twelfth thoracic vertebra, and ends opposite the middle of the body of the fourth lumbar vertebra on its left side, by dividing into the right and left common iliac arteries. It is at first centrally placed between the crura of the diaphragm, but as it descends in front of the lumbar vertebræ it leaves the middle line, and, at its bifurcation, lies a little to the left side of the spine. The spot at which the aorta bifurcates is, for all practical purposes, roughly indicated on the surface of the abdomen by a point about 1·2 cm. (½ in.) below and a little to the left of the umbilicus. But the level of its bifurcation may be more accurately determined by a line drawn across the front of the abdomen from the highest point of one iliac crest to the highest point of the other.

The inferior vena cava, which accompanies the abdominal aorta, lies to its right side. Below, the vein is in contact with the artery and on a somewhat posterior plane; but above, it is separated from the aorta by the right crus of the diaphragm, and, in consequence of the caval opening in the diaphragm being placed further forward than the opening for the aorta, is on an anterior plane.

Relations.—In front, the aorta is successively crossed from above downwards by the right lobe of the liver, the cœliac (solar) plexus, the lesser omentum, the termination of the œsophagus in the stomach, the ascending layer of the transverse meso-colon, the splenic vein or commencement of the portal vein, the pancreas, the left renal vein, the third portion of the duodenum, the mesentery, the aortic plexus of the sympathetic nerve, the internal spermatic or ovarian arteries, the inferior mesenteric artery, the median lumbar lymphatic nodes and lymphatic vessels, and the small intestines.

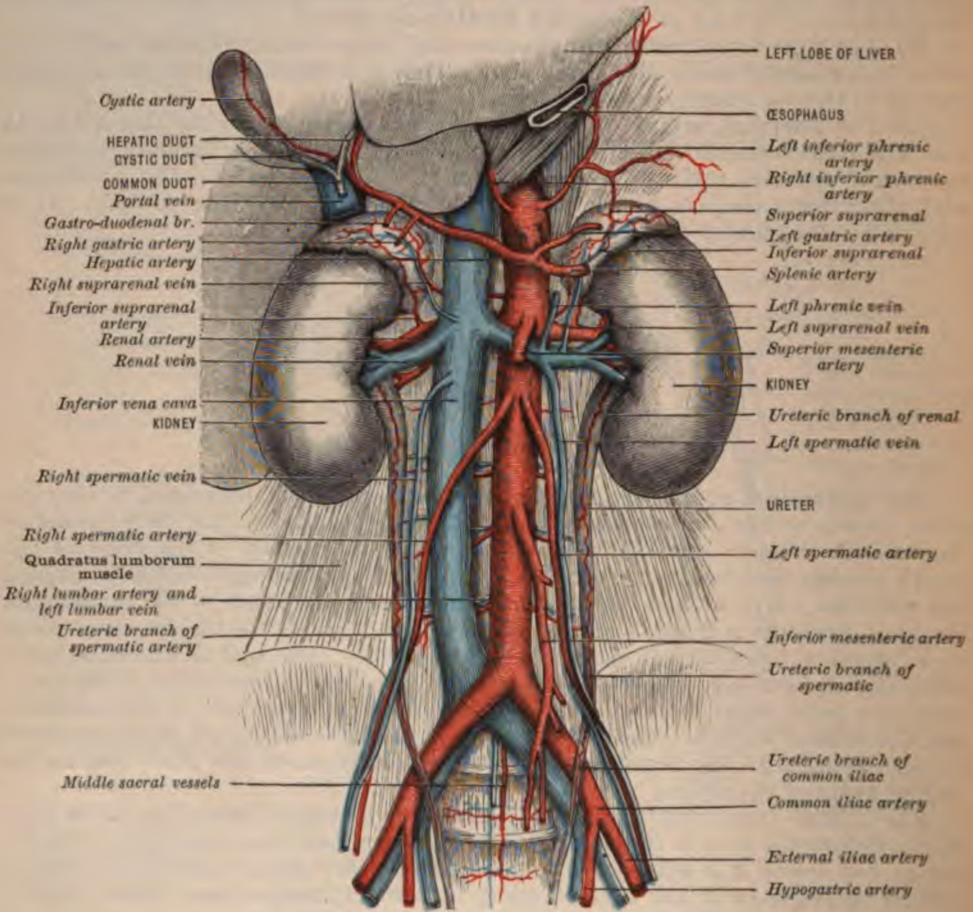
Of these structures the cœliac (solar) plexus, the aortic plexus, the splenic vein or the commencement of the portal vein, the pancreas, the left renal vein, the duodenum, the lymphatics, the spermatic or ovarian arteries, and the peritoneal reflexions are in contact with the aorta.

Behind, the aorta lies upon the bodies of the lumbar vertebræ and intervening intervertebral cartilages, the anterior longitudinal ligament, the origin of the left crus of the diaphragm, and the left lumbar veins.

On the **right side** from above downwards are the right crus of the diaphragm, the great splanchnic nerve, the caudate lobe of the liver, the receptaculum chyli and beginning of the thoracic duct (the two latter structures are on a posterior plane), the right cœliac (semilunar) ganglion, and the inferior vena cava.

On the **left side** are the left crus of the diaphragm, the left splanchnic nerve, and the left cœliac (semilunar) ganglion. The pancreas is also in contact with the aorta on the left side, and the small intestines are separated from it only by peritoneum.

FIG. 443.—THE ABDOMINAL AORTA AND ITS BRANCHES, WITH THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.


Cystic artery
HEPATIC DUCT
CYSTIC DUCT
COMMON DUCT
Portal vein
Gastro-duodenal br.
Right gastric artery
Hepatic artery
Right suprarenal vein
Inferior suprarenal artery
Renal artery
Renal vein
Inferior vena cava
KIDNEY
Right spermatic vein
Right spermatic artery
Quadratus lumborum muscle
Right lumbar artery and left lumbar vein
Ureteric branch of spermatic artery
Middle sacral vessels
LEFT LOBE OF LIVER
ŒSOPHAGUS
Left inferior phrenic artery
Right inferior phrenic artery
Superior suprarenal
Left gastric artery
Inferior suprarenal
Splenic artery
Left phrenic vein
Left suprarenal vein
Superior mesenteric artery
KIDNEY
Ureteric branch of renal
Left spermatic vein
URETER
Left spermatic artery
Inferior mesenteric artery
Ureteric branch of spermatic
Ureteric branch of common iliac
Common iliac artery
External iliac artery
Hypogastric artery

Variations in the Abdominal Aorta

Variations in the abdominal aorta, except as regards its place of division and some irregularity in the origin and number of its branches, are not common. According to Quain, in ten out of every thirteen subjects examined the bifurcation took place within 1·2 cm. (½ in.) above or below the level of the highest part of the crest of the ilium. The commonest situation for its bifurcation with reference to the vertebræ is perhaps opposite the lower border of the body of the fourth lumbar, but it may divide opposite the disc between the fourth and fifth lumbar, or rarely opposite the fifth lumbar. A higher division than at the usual spot is less common. The artery, however, has been found in exceptional instances dividing as high as the origin of the renal arteries, or even as high as the second lumbar vertebra.

The following rare variations have been met with:—(A) The aorta passing through the œsophageal opening in the diaphragm. (B) The aorta lying on the right side of the vena cava; the vein then passes over the upper part of the aorta to gain the caval opening. (C) The aorta with a vena cava on each side, the left vein passing across the upper part of the artery to open into the right vein just below the caval opening. (D) The aorta giving off a pulmonray branch close to the origin of the cœliac artery, the abnormal vessel then passing through the œsophageal opening, and supplying a branch to the lower lobe of each lung.

The variations in the branches of the aorta are described under each branch.

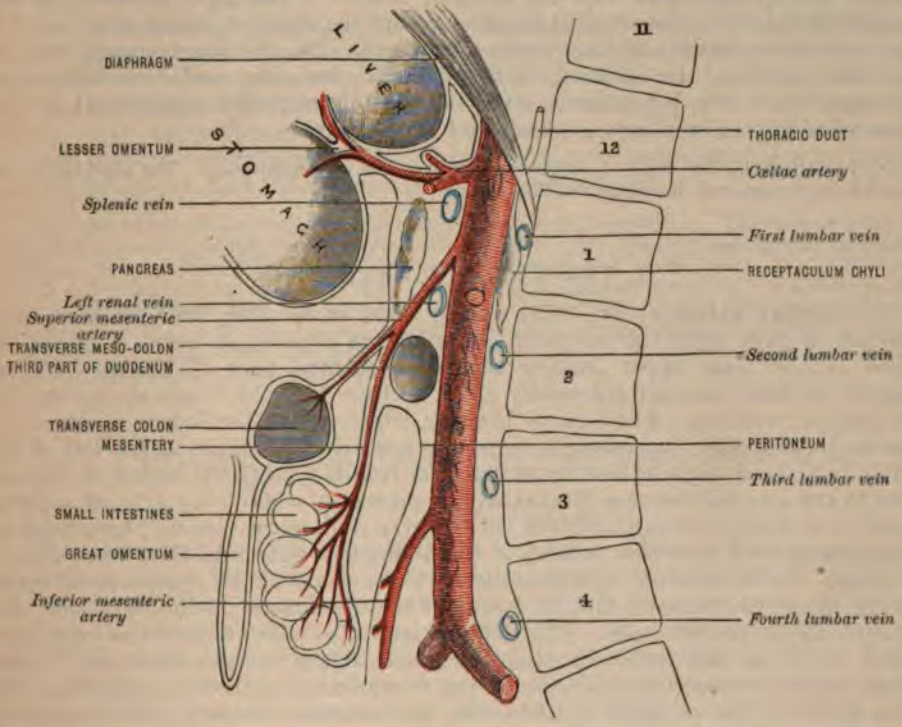
BRANCHES OF THE ABDOMINAL AORTA

The **branches of the abdominal aorta** are given off in the following order from above downwards (fig. 443):—

(1) Right and left inferior phrenic; (2) cœliac; (3) right and left middle suprarenal; (4) right and left first lumbar; (5) superior mesenteric; (6) right and left renal; (7) right and left internal spermatic; (8) right and left second lumbar; (9) inferior mesenteric; (10) right and left third lumbar; (11) right and left fourth lumbar; (12) right and left common iliac; (13) middle sacral.

The above branches may be divided into the parietal, the visceral, and the terminal.

FIG. 444.—SCHEME OF THE ABDOMINAL AORTA. (Walsham.)


DIAPHRAGM
LESSER OMENTUM
Splenic vein
PANCREAS
Left renal vein
Superior mesenteric artery
TRANSVERSE MESO-COLON
THIRD PART OF DUODENUM
TRANSVERSE COLON
MESENTERY
SMALL INTESTINES
GREAT OMENTUM
Inferior mesenteric artery
LIVER
STOMACH
11
12
1
2
3
4
THORACIC DUCT
Cœliac artery
First lumbar vein
RECEPTACULUM CHYLI
Second lumbar vein
PERITONEUM
Third lumbar vein
Fourth lumbar vein

The **parietal branches** are distributed to the abdominal walls. They are the right and left phrenics, and the four right and left lumbars.

The **visceral branches** supply the viscera. Three of these are given off singly from the front of the aorta, namely, the cœliac, the superior mesenteric, and the inferior mesenteric; and three are given off in pairs, namely, the two suprarenals, the two renals, and the two spermatics.

The **terminal branches** are the middle sacral and the right and left common iliac arteries.

A. THE PARIETAL BRANCHES OF THE ABDOMINAL AORTA.

1. THE INFERIOR PHRENIC ARTERIES

The **right** and **left inferior phrenic arteries** usually arise from the aorta as it passes between the crura of the diaphragm, either as a common trunk or as separate vessels. At times they come off as a common trunk from the cœliac artery; or either the right or left vessel may come from this artery, or from other of the upper branches of the abdominal aorta.

The **right phrenic** passes (fig. 445) over the right crus of the diaphragm behind the vena cava, and then upwards and to the right between the central and right leaflets of the central tendon of the muscle, where it divides into an **anterior** and a **posterior** branch. The former courses forwards and inwards, and anastomoses with the anterior branch of the left phrenic, with the musculo-phrenic branches of the internal mammary, and with the superior phrenic arteries; the latter passes outwards and backwards towards the ribs, and anastomoses with the intercostal arteries. Besides the two terminal branches and branches for the supply of the diaphragm itself the right phrenic gives off the **right superior suprarenal,** to the right suprarenal capsule, as well as branches to the vena cava, to the liver, and to the pericardium.

The **left phrenic** crosses the left crus of the diaphragm behind the œsophagus, and then runs between the left and central leaflets of the tendon, dividing like the right into an **anterior** and a **posterior** branch. The former runs forwards and inwards, and anastomoses with the anterior branch of the right phrenic, the left musculo-phrenic from the internal mammary, and the superior phrenic artery. The latter courses outwards and backwards towards the ribs, and anastomoses with the intercostal arteries. In addition to the terminal branches, and branches to the diaphragm itself, the left phrenic gives off the **left superior suprarenal** as well as branches to the œsophagus, spleen, and pericardium.

The **variations** in the origin of the phrenic arteries are very numerous. The chief have been alluded to in the general description of the vessels.

2. THE LUMBAR ARTERIES

The **lumbar arteries** (fig. 443), usually eight in number, four on each side, come off in pairs from the posterior aspect of the abdominal aorta, opposite the bodies of the four upper lumbar vertebræ. A fifth pair of lumbar arteries, generally of small size, are frequently given off from the middle sacral opposite the fifth lumbar vertebra. The lumbar arteries, which are rather longer on the right than on the left side, in consequence of the aorta lying a little to the left of the median line, wind more or less transversely outwards around the bodies of the vertebræ to the interval between the transverse processes, where they give off a dorsal branch, and then, coursing forwards between the abdominal muscles, terminate by anastomosing with the other arteries of the abdominal wall. As they wind around the bodies of the vertebræ they pass beneath the chain of the sympathetic nerve, and the upper two beneath the right crus of the diaphragm on the right side, and the left crus on the left side. The right arteries also pass beneath the vena cava inferior, and the two upper on that side beneath the receptaculum chyli. The arteries on both sides then dip beneath the tendinous arch thrown across the sides of the bodies of the vertebræ by the psoas, and continue beneath this muscle until they arrive at the interval between the transverse processes of the vertebræ and the inner edge of the quadratus lumborum. Whilst under cover of the psoas they are accompanied by two slender filaments of the sympathetic nerve and by the lumbar veins. A little anterior to the transverse processes they are crossed by branches of the lumbar plexus, and here usually cross in front of the ascending lumbar vein. They now pass behind the quadratus lumborum, with the exception usually of the first, and sometimes of the last, which may pass in front of the muscle. At the outer edge of the quadratus they run between the transversalis and the internal oblique, and then, perforating the internal oblique, between the internal and external oblique. Finally, much diminished in size, they enter the rectus, and give off one or more anterior cutaneous branches, which accompany the last thoracic and the ilio-hypogastric nerves to the skin. They anastomose with the lower intercostals, ilio-lumbar, deep circumflex iliac, and deep epigastric arteries.

The lumbar arteries give off the following branches:—

(*a*) **Vertebral branches** which supply the bodies of the vertebræ and their connecting ligaments.

(*b*) **Muscular branches** to the psoas, quadratus lumborum, and oblique muscles of the abdomen.

(*c*) The **dorsal branch.** This is of large size, and passes backwards in company with the dorsal nerve between the transverse processes above and below, the intertransversalis internally, and the quadratus lumborum externally, to the muscles of the back. On reaching the interval between the longissimus dorsi and multifidus spinæ, it divides into an external and internal branch. The former ends in the multifidus, the latter and larger supplies the sacro-spinalis, and gives branches which accompany the termination of the dorsal nerves to the skin. Just before the artery passes between the transverse processes it gives off a **spinal** branch, which accompanies the lumbar nerve through the intervertebral foramen into the spinal canal. Here the spinal branch divides into three twigs, one of which passes through the sheath of the dura mater to the termination of the spinal cord and cauda equina; the other two are distributed to the walls of the spinal canal after the way described in the case of the intercostals.

(*d*) **Renal branches** of small size pass forwards in front of the quadratus lumborum to the capsule of the kidney. They anastomose with the renal artery. A communication is thus established between the renal arteries and the arteries supplying the lumbar region.

The **fifth pair of lumbar arteries,** when present, usually come off from the middle sacral artery. Each courses outwards, beneath the common iliac artery and vein; and, after giving off a dorsal branch, ramifies over the lateral mass of the sacrum, and ends in the iliacus muscle by anastomosing with the circumflex iliac artery. The **dorsal branch** passes to the back between the last lumbar vertebra and the sacrum and ramifies in the gluteus maximus, anastomosing with the lumbar arteries above, and the superior gluteal artery below.

The **variations** in the lumbar arteries are not of great importance. (A) One or more pairs may arise as a common stem from the back of the aorta. (B) The first lumbar may be joined at its origin with the lowest intercostal artery; or the third and fourth lumbar, or less often the second and third lumbar, may arise from the aorta as a common stem. (C) The fifth pair may sometimes be absent. (D) The first lumbar may give off the inferior phrenic or the middle suprarenal. (E) One of the lumbar arteries may give off the internal spermatic. (F) The fourth lumbar on either side may give off the middle sacral, or both arteries may arise as a common stem with the middle sacral.

B. The Visceral Branches of the Abdominal Aorta

THE CŒLIAC ARTERY

The **cœliac artery**—or **cœliac axis,** as it is commonly called, because it breaks up simultaneously into three branches which radiate from it like the spokes of a wheel from the axle—is a short thick trunk given off from the front of the aorta between the crura of the diaphragm a little below the aortic opening. It passes horizontally forwards above the upper margin of the pancreas for about half an inch, and then breaks up into three branches for the supply of the stomach, duodenum, spleen, pancreas, liver, and gall-bladder (fig. 445).

Relations.—In front is the lesser omentum; **behind,** the aorta; **above,** the right lobe of the liver; **below,** the pancreas; to the **right,** the right cœliac (semilunar) ganglion and caudate lobe of the liver; to the **left,** the left cœliac (semilunar) ganglion and the cardiac end of the stomach. It is closely surrounded by the dense cœliac (solar) plexus of sympathetic nerves.

Variations.—(A) The cœliac artery may be absent; the branches usually arising from it then coming off separately from the aorta. (B) It may be shorter or longer than usual. Under the latter circumstance the branches are commonly given off separately from the trunk of the vessel instead of radiating from one spot. (C) It may give off two branches only: these are usually the splenic and hepatic, more rarely the gastric and the splenic. (D) It may give off more than three branches, the additional branch being one of the inferior phrenics; a trunk common to the two inferior phrenics; a gastro-duodenal; a second gastric or splenic artery, or the superior mesenteric; the median colic or the pancreatica magna. (E) One or other of the branches normal to the cœliac artery may be absent, or replaced by a stem common to the phrenics, or by the right middle suprarenal and the right gastro-epiploic, or more rarely by some other branch.

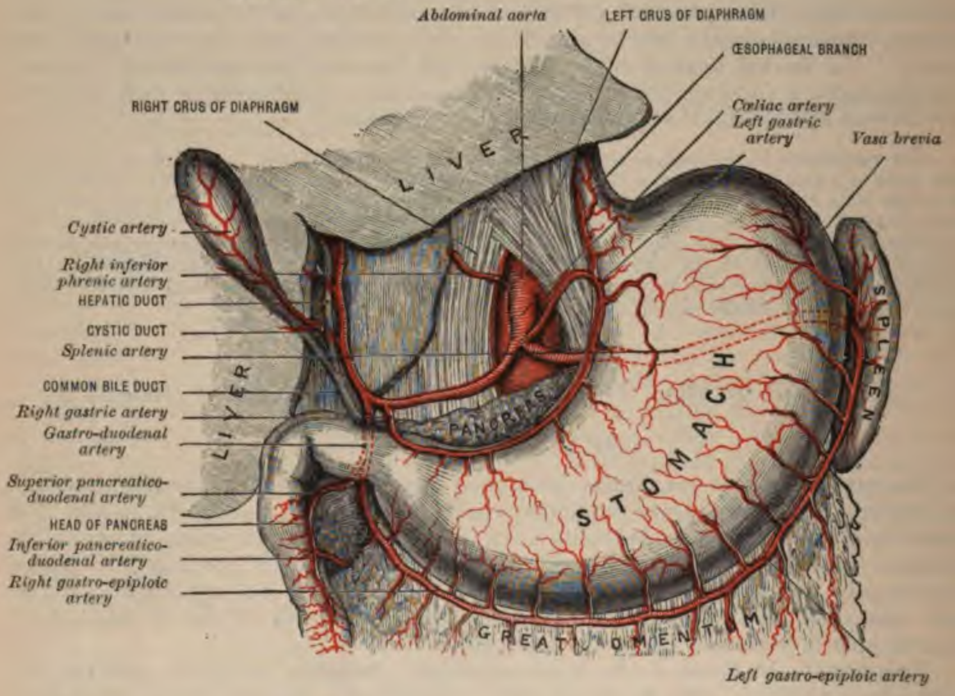
Branches of the cœliac artery.—The cœliac artery divides into the left gastric, the hepatic, and the splenic arteries.

1. The Left Gastric Artery

The **left gastric** (gastric) (fig. 445), the smallest of the three branches into which the cœliac artery divides, courses at first upwards and to the left towards the cardiac end of the stomach, where it turns sharply round, and then, coasting along the lesser curvature of the stomach, descends from left to right towards the pylorus. It anastomoses with the right gastric (superior pyloric) branch of the hepatic artery, which has proceeded from the opposite direction, the two branches thus forming a continuous arterial arch corresponding to the lesser curvature of the stomach. The artery at first lies behind the posterior layer of the lesser omental sac of peritoneum (fig. 444), but on reaching the cardiac end of the stomach it passes through the so-called pancreatico-gastric fold of peritoneum into the lesser omentum, between which it then runs to its terminal anastomosis with the pyloric. It is surrounded by the coronary plexus of sympathetic nerves.

It supplies both surfaces of the stomach around the lesser curvature and gives off small branches to the œsophagus.

Fig. 445.—The Cœliac Artery and its Branches.


Abdominal aorta
LEFT CRUS OF DIAPHRAGM
ŒSOPHAGEAL BRANCH
RIGHT CRUS OF DIAPHRAGM
Cœliac artery
Left gastric artery
Vasa brevia
LIVER
Cystic artery
Right inferior phrenic artery
HEPATIC DUCT
CYSTIC DUCT
Splenic artery
COMMON BILE DUCT
Right gastric artery
Gastro-duodenal artery
Superior pancreatico-duodenal artery
HEAD OF PANCREAS
Inferior pancreatico-duodenal artery
Right gastro-epiploic artery
LIVER
PANCREAS
STOMACH
SPLEEN
GREAT OMENTUM
Left gastro-epiploic artery

Chief variations.—(A) The left gastric may arise directly from the aorta, and may then give off one of the inferior phrenics, or both, or a trunk common to the two. (B) There may be two left gastric arteries instead of one. (C) The left gastric may give off the left branch of the hepatic artery. This appears to be due to the enlargement of the constantly present small hepatic branch, and the obliteration of part of the normal left branch of the hepatic artery

2. The Hepatic Artery

The **hepatic artery,** the largest branch of the cœliac artery in the fœtus, but intermediate in the adult between the left gastric and the splenic, comes off on the right side of the cœliac artery, and, winding upwards and to the right to the transverse or portal fissure of the liver, there breaks up into two chief branches for the supply of the right and left lobe of that organ. It at first courses forwards and to the right along the upper border of the head of the pancreas, behind the posterior layer of the lesser omental sac of peritoneum, to the upper margin of the duodenum, where, at the base of the so-called right pancreatico-gastric fold, it passes between the two layers of the lesser omentum, and thus ascends along with the hepatic duct which lies to its right, and with the portal vein which lies behind it, to the transverse or portal fissure of the liver. As it lies with the hepatic duct and portal vein between the layers of the lesser omentum, it is in front of the so-called foramen of Winslow.

The **branches of the hepatic artery** are:—(1) The right gastric (superior pyloric); (2) the gastro-duodenal; (3) the right terminal; and (4) the left terminal. **Pancreatic,** or **lesser pancreatic, branches** as they are often called, are also given off from the hepatic as it runs along the upper margin of the pancreas.

(1) The **right gastric** comes off from the hepatic just as the latter vessel enters the lesser omentum, and, descending between the two layers of that fold of peritoneum to the pylorus, there turns to the left, and, ascending from right to left, anastomoses along the lesser curvature of the stomach, as already mentioned, with the left gastric (gastric) artery, which descends from the opposite direction.

(2) The **gastro-duodenal** arises from the hepatic a little beyond the pyloric. It descends behind the ascending portion of the duodenum to the lower border of the pylorus, where it divides into the **right gastro-epiploic** and the **superior pancreatico-duodenal.** It varies from 1·2 to 2·5 cm. (½ to 1 in.) in length. In addition to the above branches it may give off the **inferior pyloric artery.**

(*a*) The **right gastro-epiploic,** entering the anterior fold of the great omentum, coasts from right to left along the greater curvature of the stomach, and anastomoses with the **left gastro-epiploic branch** of the splenic, which descends from left to right also along the greater curvature to meet it. From this anastomotic arch are given off:—(i) **Ascending** or **gastric branches,** which supply the anterior and posterior surfaces of the stomach, and anastomose with the descending gastric branches of the arteries along the lesser curvature. (ii) **Epiploic** or **omental branches**—long slender vessels which descend between the two anterior layers of the great omentum, and then, looping upwards, anastomose with similar slender branches given off from the middle and left colic, and passing down in like manner between the two posterior layers of the great omentum.

(*b*) The **superior pancreatico-duodenal**—the smaller division of the gastro-duodenal—arises from that vessel as it passes behind the first portion of the duodenum, and courses downwards behind the peritoneum, in the anterior groove between the second portion of the duodenum and the pancreas, to anastomose with the inferior pancreatico-duodenal, a branch of the superior mesenteric, which runs upwards between the contiguous borders of the pancreas and duodenum. Both the inferior and superior pancreatico-duodenal give off branches to the duodenum and the pancreas.

(*c*) The **inferior pyloric** arises either from the gastro-duodenal or from the right gastro-epiploic; it supplies the pyloric end of the stomach, and anastomoses with the other arteries in that situation.

(3) The **right terminal branch** is given off at the portal fissure of the liver, and runs to the right towards the end of that fissure, either behind the hepatic and cystic ducts, or between these structures. At the right end of the fissure it divides into two or more branches, which again subdivide as they enter the liver substance for the supply of the right lobe. As it crosses the cystic duct it gives off the cystic artery.

(*a*) The **cystic artery** courses forwards and downwards through the angle formed by the union of the hepatic and cystic ducts, and just before it reaches the gall-bladder divides into a superficial and deep branch. The former breaks up into a number of small vessels, which ramify over the free surface of the gall-bladder beneath the peritoneal covering, and furnish branches to the muscular and mucous coats. The deep branch ramifies between the gall-bladder and the liver-substance, supplying each, and anastomosing with the superficial branch.

(4) The **left terminal branch,** the smaller division of the hepatic artery, runs inwards towards the left end of the portal fissure, and, after giving off a distinct branch to the caudate (Spigelian) lobe, enters the left lobe of the liver.

Chief variations.—(A) The hepatic artery may arise directly from the aorta, or from the left gastric (gastric), the superior mesenteric, or the right renal artery. (B) Together with a normal artery there may be an accessory hepatic from one or other of the above-named or neighbouring branches. (C) The hepatic artery may be altogether wanting, and its place supplied by one or more accessory arteries derived from one or other of the above-named sources. This variation is explained by Hyrtl on the supposition that there has been obliteration of the normal hepatic, with enlargement of one or more of the minute branches which normally proceed from the aorta and the above-named branches to the capsule of the liver.

3. THE SPLENIC ARTERY

The **splenic artery**—the largest branch of the cœliac artery—arises from the left side of the termination of that vessel below the left gastric, and passes along the upper border of the pancreas in a tortuous manner to the spleen. It at first lies behind the ascending layer of the transverse meso-colon, but on nearing the spleen enters the lieno-renal ligament, and there breaks up into numerous branches, which enter the hilus and supply the organ. In this course it crosses in front of the left crus of the diaphragm and the upper end of the left kidney and is placed above the splenic vein.

The **branches of the splenic artery** are:—(1) The pancreatic; (2) the left gastro-epiploica; (3) the vasa brevia; and (4) the terminal.

(1) The **pancreatic branches** come off from the splenic at varying intervals, as that vessel courses along the upper margin of the pancreas. They enter and supply the organ.

One **larger branch** usually arises from the splenic about the junction of its middle with its left third. Entering the pancreas obliquely, it runs from left to right, commonly above, and a little behind, the pancreatic duct, which it supplies together with the substance of the organ.

(2) The **left gastro-epiploic** arises from the splenic behind the great *cul-de-sac* of the stomach, and, passing between the anterior layers of the great omentum, descends along the greater curvature of the stomach from left to right, and anastomoses with the right gastro-epiploic. Like that vessel, it gives off **ascending** or **gastric branches** to the anterior and posterior surfaces of the stomach respectively, and long slender **descending epiploic** or **omental branches** to the great omentum which anastomose with like branches from the right and left colic arteries.

(3) The **vasa brevia** come off from the splenic just before it divides into its terminal branches, oftentimes from some of these terminal branches themselves. Passing from between the folds of the lieno-renal ligament into those of the gastro-lienal, they thus reach the greater *cul-de-sac* of the stomach, where, ramifying over both its anterior and posterior surfaces, they anastomose with the left gastric and left gastro-epiploic arteries.

(4) The **splenic** or **terminal branches,** five to eight or more in number, are given off from the splenic as it lies in the lieno-renal ligament, and, entering the spleen at the hilum, are distributed in the way mentioned in the description of that organ.

The **variations of the splenic artery** are neither numerous nor important. (A) It may divide into two branches which reunite, the splenic vein running through the loop thus formed. (B) It may sometimes give off branches normally derived from other vessels, such as the left gastric (gastric), the middle colic, and the left hepatic. (C) The variations in its origin are mentioned under VARIATIONS OF THE CŒLIAC ARTERY (p. 593).

THE SUPERIOR MESENTERIC ARTERY

The **superior mesenteric artery** is given off from the front of the aorta a little below the cœliac, which it nearly equals in size; sometimes it forms a common trunk with the cœliac. Lying at first behind the pancreas and splenic vein, it soon passes forwards between the lower border of that gland and the upper border of the third portion of the duodenum, and, crossing in front of the duodenum, enters the mesentery, in which it runs from left to right, in the form of a curve with its convexity to the left, to the cæcum, where it anastomoses with its ileo-colic branch. Its vein lies to its right side above, having previously crossed obliquely in front of the artery from left to right. It is surrounded by the mesenteric plexus of nerves. The accessory portion of the head of the pancreas dips in behind the vessel.

From the concave side of the artery branches are given off to the duodenum and the colon, viz.:—

(1) The inferior pancreatico-duodenal; (2) the middle colic; (3) the right colic; and (4) the ileo-colic.

From the convex side branches are given off to the small intestines, viz.:—

(5) The intestinal arteries.

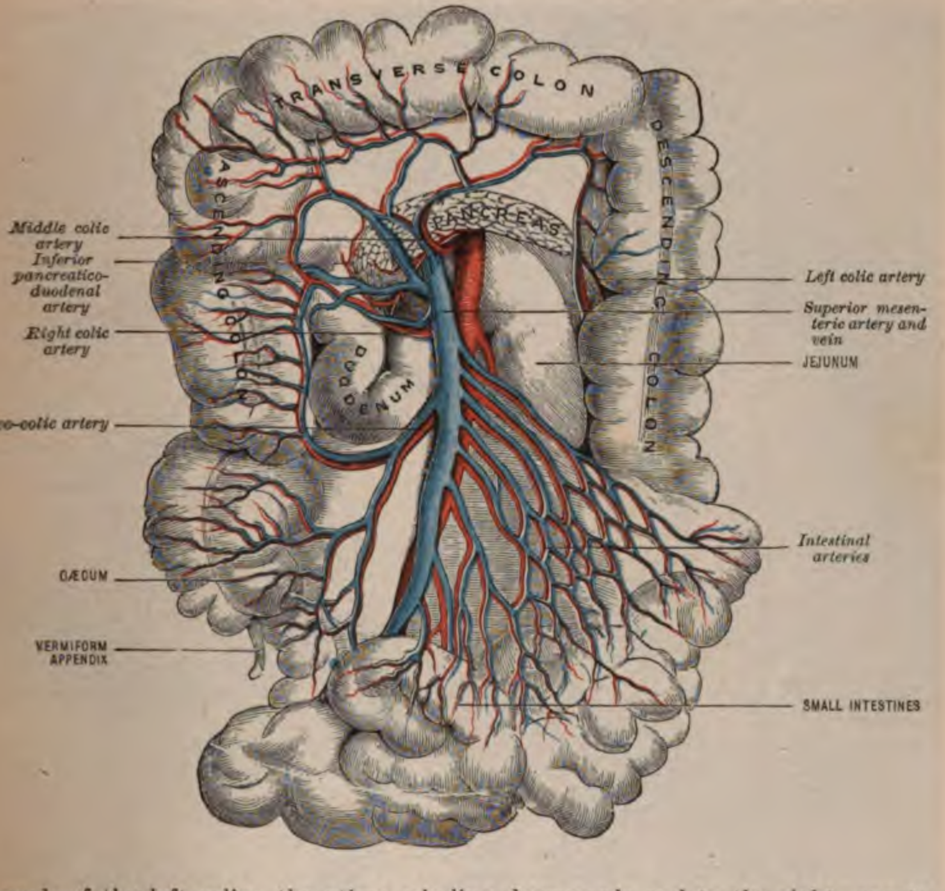
It will thus be seen that the superior mesenteric artery supplies, with the exc tion of the upper third of the duodenum, the whole of the small intestine and half the large.

(1) The **inferior pancreatico-duodenal** arises either from the superior mesenteric as that vessel emerges from the contiguous margins of the pancreas and transverse duodenum or from its first intestinal branch, and, crossing behind the superior mesenteric vein, courses upwards and to the right between the head of the pancreas and the duodenum, beneath the ascending layer of the transverse meso-colon, to anastomose with the superior pancreatico-duodenal, which is given off from the gastro-duodenal, and descends in a like situation beneath the ascending layer of the transverse meso-colon.

(2) The **middle colic,** arising from the concavity of the superior mesenteric a little below the pancreas, enters the transverse meso-colon, and divides into two branches—one of which passes to the left and anastomoses with the ascending branch of the left colic; the other, winding downwards and to the right, anastomoses with the ascending branch of the right colic.

FIG. 446.—THE SUPERIOR MESENTERIC ARTERY AND VEIN.

(The colon is turned up, and the small intestines are drawn over to the left side.)

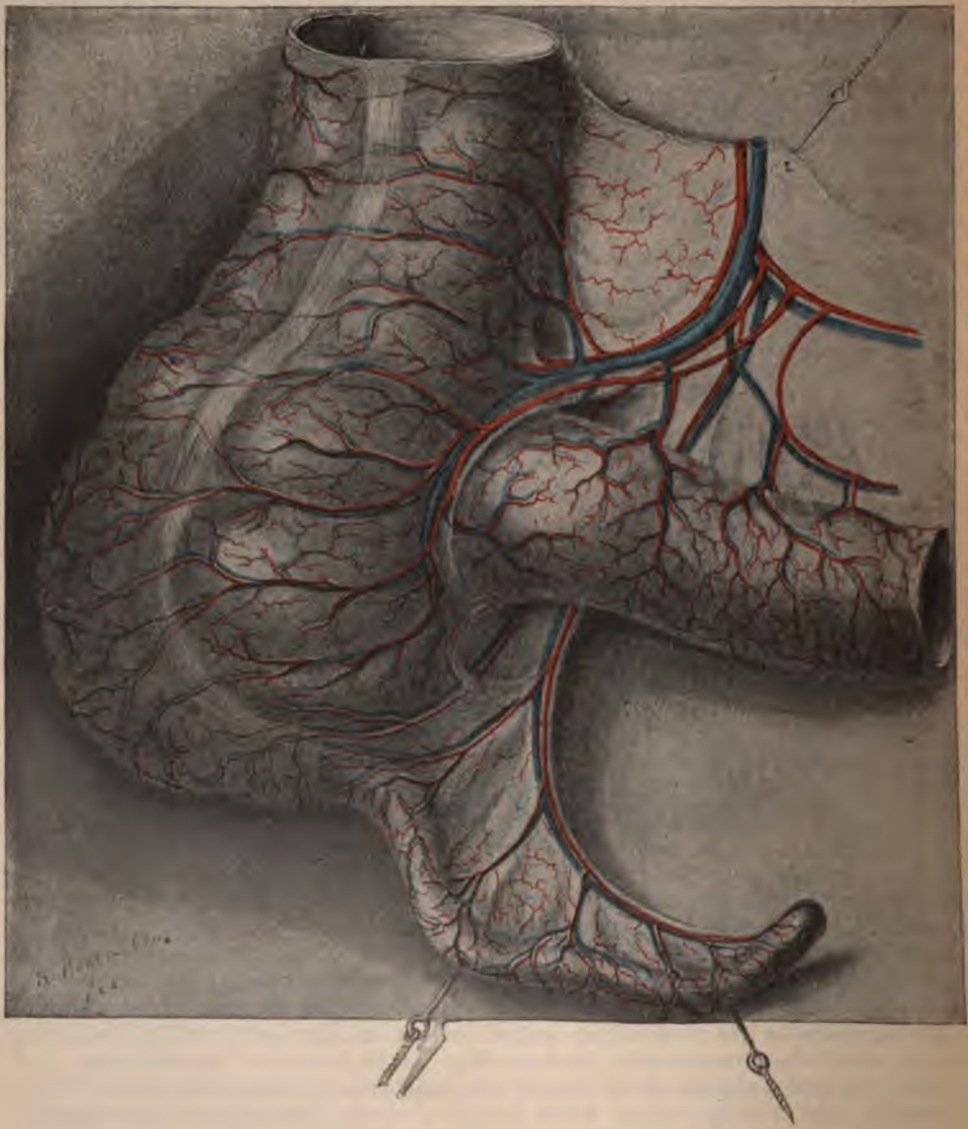

TRANSVERSE COLON
ASCENDING COLON
DESCENDING COLON
PANCREAS
DUODENUM
Middle colic artery
Inferior pancreatico-duodenal artery
Right colic artery
Ileo-colic artery
CÆCUM
VERMIFORM APPENDIX
Left colic artery
Superior mesenteric artery and vein
JEJUNUM
Intestinal arteries
SMALL INTESTINES

(3) The **right colic**—sometimes given off as a common trunk either with the former branch or with the ileo-colic—passes to the right behind the peritoneum to the back of the ascending colon, where it divides into an ascending branch, which anastomoses with the descending branch of the middle colic, and a descending branch which anastomoses with the ascending or colic branch of the ileo-colic.

(4) The **ileo-colic** descends behind the peritoneum towards the cæcum, where it divides into a colic branch which tracks upwards beneath the peritoneum to anastomose with the descending branch of the right colic; and into an iliac branch which passes between the layers of the mesentery and anastomoses with the termination of the superior mesenteric artery.

Fig. 447.—The Blood-vessels of the Ileo-cæcal Region. (From Kelly.)

(Arteries red, veins blue. The peritoneal covering is removed so as to show the vessels more clearly. Above and to the right are seen the cut ends of the ileo-colic artery and vein. This artery gives off a branch to the ascending colon and a posterior and anterior cæcal artery, the latter descending through the ileo-colic fold. A short anastomosis connects the ileo-colic with the mesenteric. The artery of the appendix is seen to arise from the posterior cæcal artery, 2 cm. above the ileum. It passes behind the ileum in the free border of the mesappendix and gives off five branches (long appendices have 8–12, short appendices, 2–3), which traverse the mesappendix at fairly regular intervals in the direction of the hilus of the appendix, where they divide into anterior and posterior branches. The branches in the mesappendix are sometimes seen to anastomose, forming loops of varying size. The terminal branch curves around the tip. The cæco-appendical junction is supplied by a separate branch arising likewise from the posterior ileo-cæcal trunk. This branch may or may not anastomose with the proximal appendical twig and while in some cases it supplies only the cæcum, in others, as in the present case, it sends a few delicate branches into the appendix. At the place where this cæco-appendical artery crosses the ileo-cæcal fold it is seen to give off a delicate recurrent twig to this structure. Throughout their entire course the arteries are accompanied by veins.)



From the anastomotic loops formed between the termination of the superior mesenteric, the ileo-colic, the right colic, and the middle colic arteries, secondary loops are derived whence branches pass to the termination of the ileum, the cæcum, the vermiform appendix, the ascending colon, and half the transverse colon. These branches on reaching the intestine divide into two, one of which passes in front and the other behind the intestine, and, after encircling it, anastomose with each other and with the neighbouring circlets above and below.

(5) The **intestinal branches,** or **vasa intestini tenuis,** arise from the convex side of the superior mesenteric, and, varying from twelve to sixteen in number, radiate in the mesentery, where each divides into two branches, which inosculate with similar branches given off from the branch above and below. From the primary loops thus formed, secondary loops are derived in like manner, and from these tertiary, and at times quaternary, or even quinary loops. From the ultimate loops terminal branches pass on to the intestine through the triangular interval left at the spot where the mesentery is reflected on to the muscular coat of the gut. On reaching the wall of the gut these terminal vessels bifurcate, the two branches encircling the intestine, and thus forming with those above and below a series of vascular rings surrounding the small intestine throughout its whole length. These branches of the superior mesenteric in their course to the intestine also supply the mesentery and the mesenteric glands.

The **variations in the superior mesenteric artery** are numerous. (A) It may be double. (B) It may give off accessory branches to the liver, stomach, pancreas, spleen, and gall-bladder. (C) It may give off branches normally derived from other sources, namely, the hepatic or its right or left branch, the cystic, the gastro-duodenal or its right gastro-epiploic branch, the left gastric (gastric) or the larger pancreatic branch. (D) It may give off the left colic and superior hæmorrhoidal, thus taking the place in whole or in part of the inferior mesenteric. (E) Its colic and intestinal branches may vary considerably in their origin and course, and in the number of primary and secondary loops that they form. (F) A rare abnormality described by Hyrtl is the persistence of an omphalo-mesenteric artery running to the neighbourhood of the umbilicus and giving off a branch to the urachus, or a branch to the liver through the falciform ligament, or a branch to the rectus anastomosing with the epigastric.

THE RENAL ARTERIES

The **renal arteries** come off one on each side of the abdominal aorta, a little below the superior mesenteric and first lumbar arteries, on a level with the first lumbar vertebra. They pass transversely outwards across the crura of the diaphragm to the kidneys, the right being on a slightly lower plane and somewhat longer than the left, and passing behind the inferior vena cava. In front of each is the corresponding renal vein, and behind, at the hilus of the kidney, is the commencement of the ureter. Each artery as it enters the hilus usually divides into three main stems, one of which passes towards the upper part of the pelvis, a second to its middle portion, and a third to its lower. Each of these primary stems then divides so that there result from seven to nine secondary branches, the majority of which pass anterior to the pelvis, while the remainder are posterior to it (fig. 448). No anastomoses take place between the branches of the anterior and posterior secondary stems and hence a longitudinal incision into the kidney along its curved border, half way between the anterior and posterior calices, will cut only terminal arteries.

Each renal artery gives off the following branches:—

(*a*) The **inferior suprarenal,** which ascends to the suprarenal body.

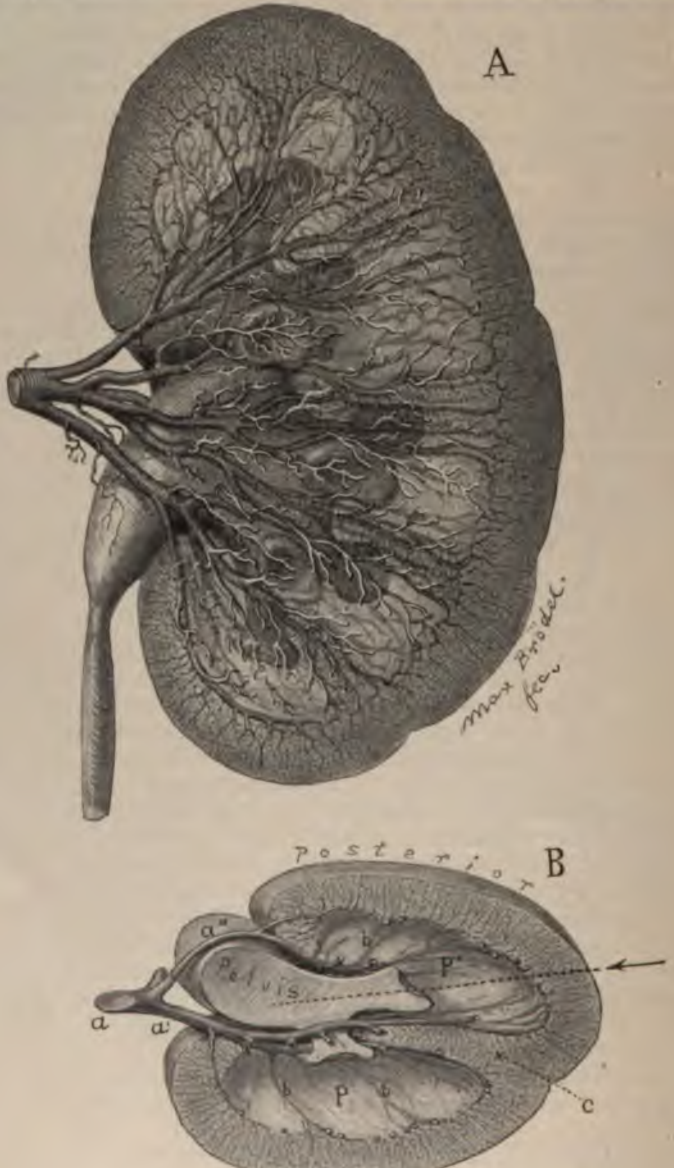
(*b*) The **capsular** or **peri-renal branches** to the capsule of the kidney and peri-renal fat.

(*c*) The **ureteral branch** to the upper end of the ureter.

Variations in the renal arteries are common. (A) The right and left renal may arise from the aorta by a common stem. (B) They may arise from the aorta lower than usual; the kidneys then being also below their usual situation. (C) There may be several renal arteries on each side, or the renal artery may divide close to its origin into several branches. (D) The renal artery on one or both sides may arise from the bifurcation of the aorta, from the common iliac, the hypogastric (internal iliac), the inferior mesenteric, or the middle sacral artery. (E) The right artery may cross in front of, instead of behind, the vena cava. (F) The branches of the renal artery may perforate the substance of the kidney instead of entering at the hilus. (G) The renal artery may give origin to branches normally derived from other vessels, as the inferior phrenic, the hepatic or its right branch from the right renal, the middle suprarenal, some of the colic arteries, the internal spermatic, one or more of the lumbar arteries, or the greater pancreatic artery. (H) Accessory renal arteries, varying in size and generally derived from the aorta, are common. They may enter the kidney at almost any part of the organ.

Fig. 448.—A. The Renal Artery and the Distribution of its Branches in Relation to the Pelvis. B. Transverse Section through the Middle of the Same Kidney. (After Brödel, Johns Hopkins Bulletin.)

a, renal artery; *a'* and *a''*, its anterior and posterior branches; *b*, branches to pyramids; *c*, line of division between anterior and posterior pyramids. The arrow and dotted line indicate the line of separation between the terminals of the anterior and posterior branches.



THE SUPRARENAL ARTERIES

The **suprarenal arteries** are derived from three sources, and are named follows:—(1) Superior suprarenal; (2) middle suprarenal; and (3) inferior supr renal.

(1) The **superior suprarenals,** one on each side, are usually derived from t *phrenics,* and descend to the suprarenal bodies.

(2) The **middle suprarenals,** or suprarenals proper, come off one on each side from the aorta, just above the first lumbar artery, and pass transversely outwards to the suprarenal bodies, across the crura of the diaphragm a little above the renal arteries. In the fœtus they equal the renals in size. In the adult they are much smaller.

(3) The **inferior suprarenals** are branches of the renals. They ascend, one on each side, to the suprarenal bodies.

For the distribution of the suprarenal vessels within the suprarenal bodies, see Section XI.

THE INTERNAL SPERMATIC ARTERIES

The **internal spermatic arteries** (fig. 443) come off from the front of the abdominal aorta. They diverge from each other as they descend over the aorta and psoas muscle to the abdominal inguinal (internal abdominal) ring, where they are joined by the vas deferens, and, passing with it through the inguinal canal and out of the subcutaneous inguinal (external abdominal) ring, run downwards into the scrotum in a tortuous course to the testes. They terminate in branches to the epididymis and body of those organs. Within the abdomen they lie beneath the peritoneum, and cross in their descent over the ureters and distal ends of the external iliac arteries; the right being superficial to the vena cava, and behind the termination of the ileum; and the left beneath the sigmoid colon. In the inguinal canal and in the scrotum the spermatic veins lie in front of the artery, and the vas deferens lies behind it.

In the fœtus these vessels pass transversely outwards to the testis, which in early fœtal life lies in the loin in front of the kidney; but as the testes descend to the scrotum, the vessels become elongated, and are drawn with the testis into the scrotum.

The spermatic arteries give off the following branches:—(1) Ureteral; (2) cremasteric; (3) epididymal; and (4) testicular.

(1) The **ureteral** are small branches given off to the ureter as the spermatic artery crosses it. They anastomose with the other ureteral branches derived from the renal, common iliac, and vesical arteries.

(2) The **cremasteric** are small branches given off to the cremaster muscle; they anastomose with the cremasteric branch of the deep epigastric.

(3) The **epididymal** are distributed to the epididymis, and anastomose with the artery of the vas.

(4) The **testicular** are the terminal branches of the spermatic; they perforate the tunica albuginea posteriorly, and are distributed to the body of the organ in the way mentioned in the section on the TESTIS.

The external spermatic artery is a branch of the inferior epigastric artery (p. 613).

Chief variations in the spermatic arteries.—(A) One or both may be wanting, the testis being then supplied by branches from the vesical or prostatic arteries passing under the arch of the pubis. (B) One or both may arise from the renal, more rarely from the middle suprarenal. (C) One may come off higher than the other. (D) They may come off from a common stem. (E) One or both may be double in the whole or part of their course. (F) The right spermatic may run behind instead of in front of the inferior vena cava.

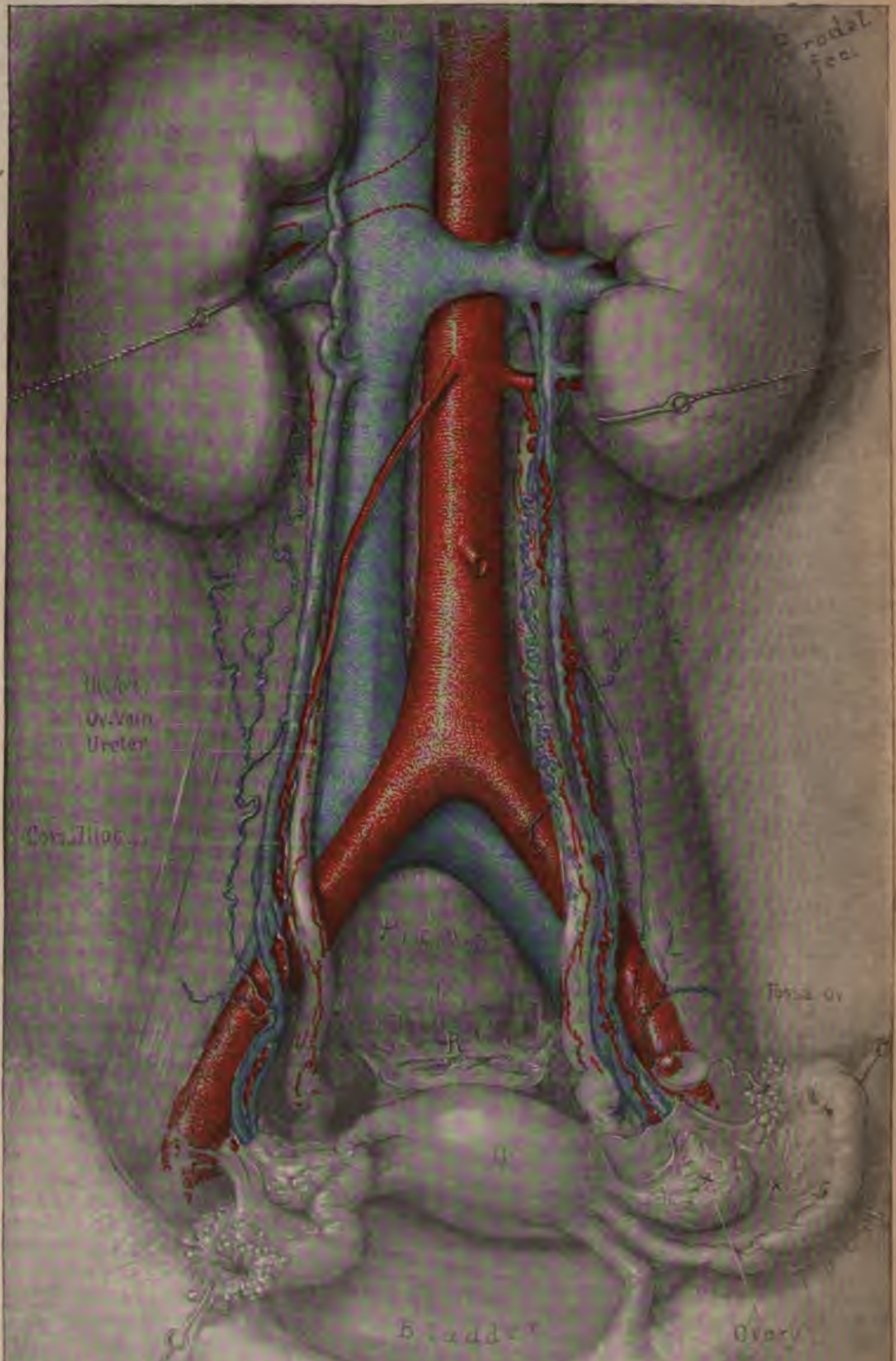
THE OVARIAN ARTERIES

The **ovarian arteries** are the homologues of the internal spermatic arteries in the male, and correspond in their relations in the upper part of their course. They diverge somewhat less, however, and, on reaching the level of the common iliac artery, turn inwards over that vessel and descend tortuously into the pelvis between the folds of the broad ligament to the ovaries. In the broad ligament the ovarian artery lies below the Fallopian tube, and on reaching the ovary turns backwards and supplies that organ. In fig. 450 is shown how the artery enters the hilus of the ovary and breaks up into branches which determine the lobules of the organ.

They give off the following branches:—(1) Ureteral; (2) tubal; (3) uterine; and (4) ligamentous.

(1) The **ureteral** is distributed, as in the male, to the ureter.

FIG. 449.—THE VASCULAR TRUNKS OF THE LOWER ABDOMEN. (From Kelly, by Brödel.)

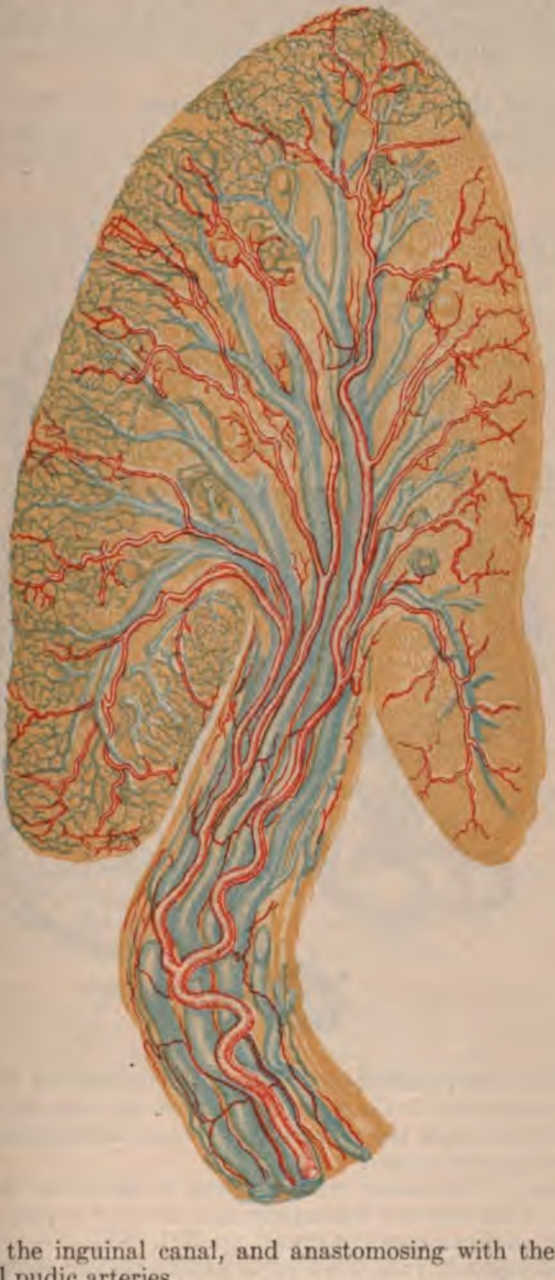

Brödel fec.
Ov. Art.
Ov. Vein
Ureter
Com. Iliac
Prom.
Fossa ov.
R
U
Bladder
Ovary
Rd. lig.

(2) The **tubal** supplies the isthmus and ampulla of the tuba uterina (Fallopian tube) and its fimbriated extremity.

(3) The **uterine** runs beneath the tuba uterina (Fallopian tube) to the uterus, supplying the upper part of the fundus, and anastomosing with the uterine arteries from the internal iliac.

(4) The **ligamentous** is distributed to the round ligament, passing with that structure through the inguinal canal, and anastomosing with the cremasteric and superficial external pudic arteries.

FIG. 450.—THE OVARIAN VESSELS. (After Clark.)



Like the spermatic, the ovarian arteries in the fœtus come off at right angles to the aorta, and pass transversely outwards to the ovaries, which are formed, as are the testes, in the right and left loin in front of the kidneys. They elongate as the ovaries descend into the pelvis. During pregnancy these arteries undergo great enlargement.

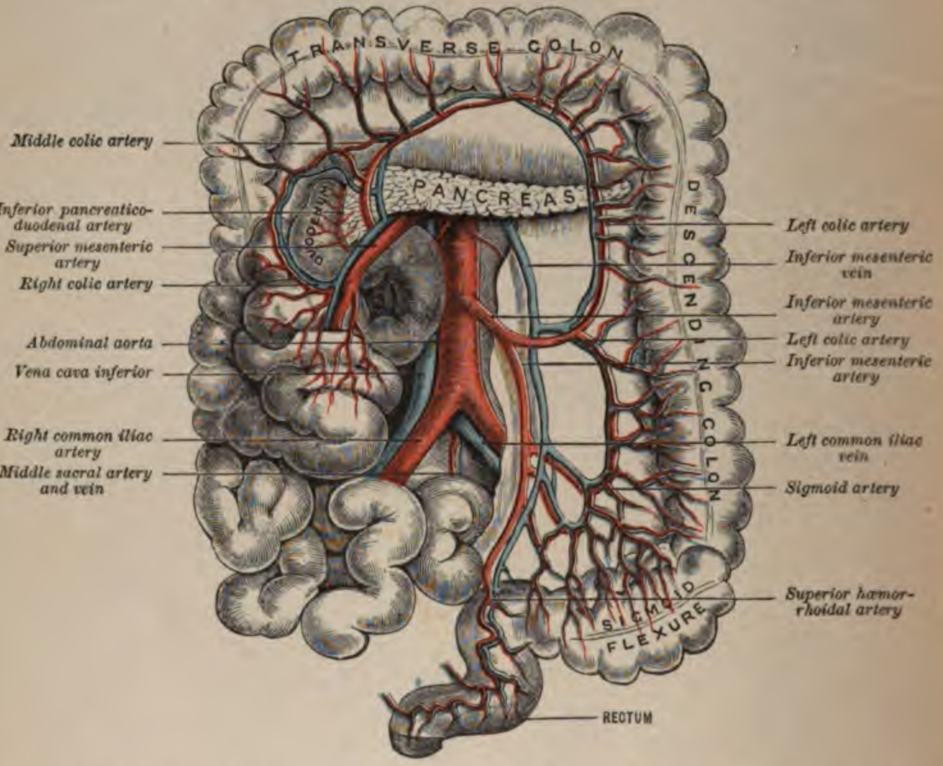
THE INFERIOR MESENTERIC ARTERY

The **inferior mesenteric artery,** smaller than the superior, arises from the front of the abdominal aorta about 3·7 cm. (1½ in.) above the bifurcation of that vessel. It runs obliquely downwards and to the left, across the lower part of the abdominal aorta and then over the left psoas muscle and left common iliac artery, descends into the pelvis between the layers of the meso-rectum, and terminates on the rectum in the superior hæmorrhoidal artery. It at first lies behind the peritoneum, or in the left lumbar meso-colon when that structure is present. It supplies the lower half of the large intestine. Its vein lies at first close to the left side, but soon passes upwards on the psoas, away from the artery, to end in the splenic vein (fig. 451).

The **branches of the inferior mesenteric** are:—(1) The left colic; (2) the sigmoid; and (3) the superior hæmorrhoidal.

(1) The **left colic** runs transversely outwards and to the left, beneath the peritoneum, and divides into two branches, one of which, entering the transverse meso-colon, ascends upwards and to the right, to anastomose with the middle colic. The other descends, and, entering the sigmoid meso-colon, anastomoses with the ascending branch of the sigmoid artery.

FIG. 451.—THE INFERIOR MESENTERIC ARTERY AND VEIN.
(The colon is turned up, and the small intestines are drawn to the right side.)


TRANSVERSE COLON
Middle colic artery
PANCREAS
DUODENUM
Inferior pancreatico-duodenal artery
Superior mesenteric artery
Right colic artery
Abdominal aorta
Vena cava inferior
Right common iliac artery
Middle sacral artery and vein
DESCENDING COLON
Left colic artery
Inferior mesenteric vein
Inferior mesenteric artery
Left colic artery
Inferior mesenteric artery
Left common iliac vein
Sigmoid artery
Superior hæmorrhoidal artery
SIGMOID FLEXURE
RECTUM

The distribution of this artery and the next to the colon is similar to that of the colic branches of the superior mesenteric, and does not require a separate description. (See SUPERIOR MESENTERIC ARTERY, pp. 592, 593.)

(2) The **sigmoid artery** runs downwards and to the left over the psoas muscle and, entering the sigmoid meso-colon, divides into two branches; the upper anastomosing with the left colic, the lower with the superior hæmorrhoidal.

(3) The **superior hæmorrhoidal** is the continued trunk of the inferior mesenteric. It descends into the pelvis, behind the rectum, between the layers of the meso-rectum. On reaching the wall of the bowel it bifurcates, one branch proceed-

ing on either side of the gut, to within 10 or 12 cm. (4 or 5 in.) of the anus. Here each again divides, and the branches, piercing the muscular coat, descend between that coat and the mucous membrane, forming with each other, and with the middle hæmorrhoidal arteries—derived from the hypogastric (internal iliac)—a series of small vessels, running longitudinally to the rectum, and parallel to each other as far as the level of the internal sphincter, where, by their anastomosis, they form a series of loops around the lower part of the rectum.

The **chief variations in the inferior mesenteric** are:—(A) Its place may be supplied by the superior mesenteric. (B) It may give branches to the liver or kidney. (C) It may give off the middle colic. (D) It may give off a stem to both umbilical arteries. (E) The anastomosis between the middle and left colic arteries may be wanting—the normal condition in the ruminants and the porcupines.

C. THE TERMINAL BRANCHES OF THE ABDOMINAL AORTA

THE MIDDLE SACRAL ARTERY

The **middle sacral artery** is, anatomically, the continuation of the aorta, and is generally held to be the homologue of the sacral and coccygeal aorta of some animals. The so-called coccygeal glomerulus, or Luschka's gland, in which it terminates, is believed to contain the rudiments of the caudal aorta, or artery of the tail. The artery is mesially placed, and extends from the bifurcation of the aorta to the tip of the coccyx. As it passes downwards into the pelvis, it runs behind the left common iliac vein, the hypogastric plexus of the sympathetic nerve, and the layer of peritoneum that descends from the mesentery into the pelvis to become the meso-rectum. It lies successively upon the intervertebral disc between the fourth and fifth lumbar vertebræ, the fifth lumbar vertebra, the intervertebral disc between that vertebra and the sacrum, and lower down upon the middle of the anterior surface of the sacrum and coccyx.

Branches.—The middle sacral gives off:—

(1) The **fifth pair of lumbar arteries** (sometimes). These are described with the lumbar arteries.

(2) **Lateral sacral branches,** usually four in number. These are serially homologous with the intercostal and lumbar arteries given off by the aorta. They run more or less transversely outwards, and anastomose with the lateral sacral branches of the hypogastric (internal iliac) artery. They give off small spinal branches, which pass through the sacral foramina, and supply the sacral canal and back of the sacrum.

(3) **Rectal** or **hæmorrhoidal branches** pass forwards in the layers of the meso-rectum to the rectum, which they help to supply, and anastomose with the other hæmorrhoidal or rectal arteries.

On the lower part of the middle sacral artery—the coccygeal part—there are often found small pouches or varicosities, which are believed by some to represent the rudiments of lateral coccygeal arteries, homologous to the intercostal, lumbar, and sacral arteries, given off from the aorta in these regions.

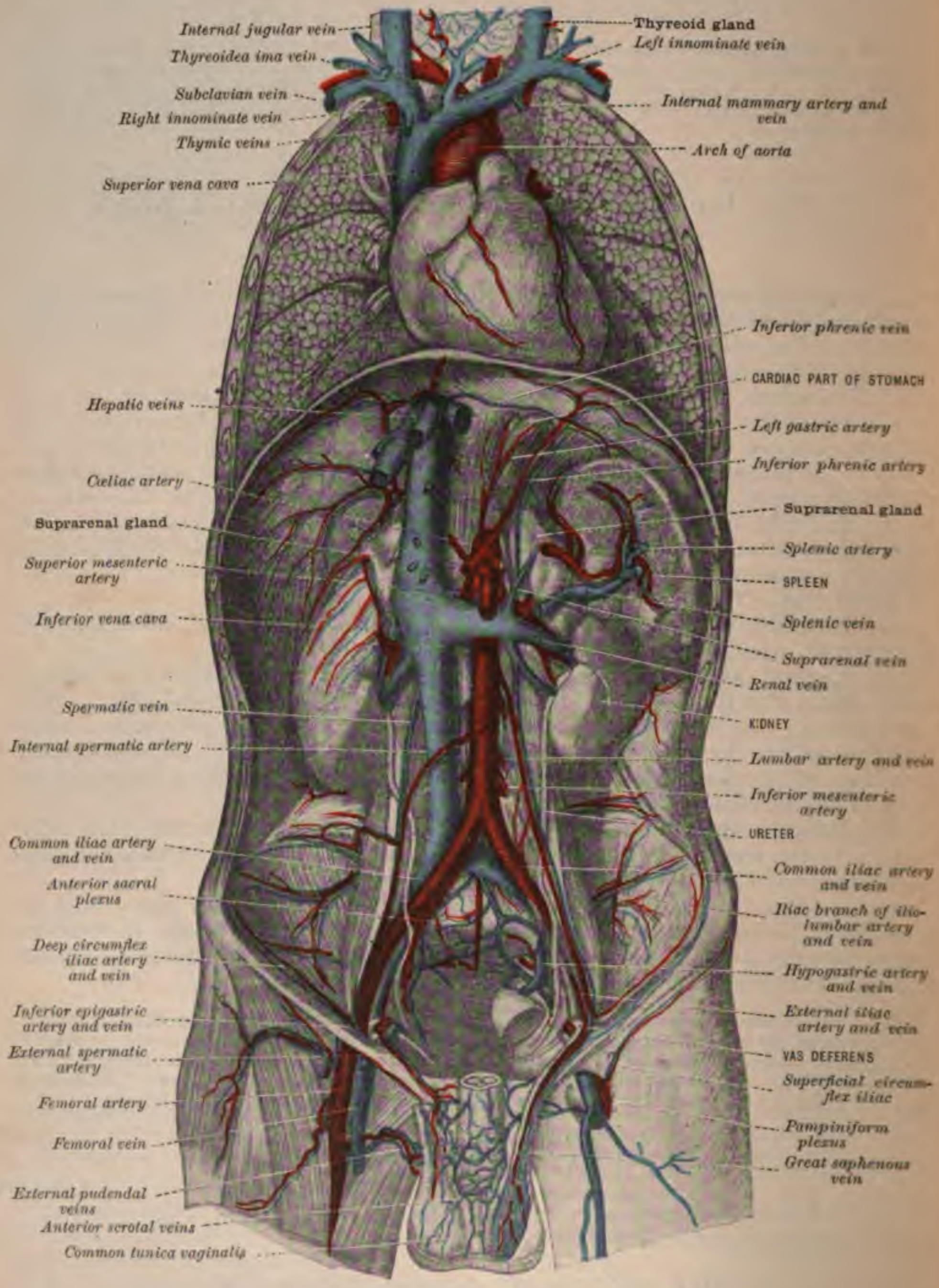
The **variations** of this vessel are unimportant. (A) The most frequent perhaps is for it to come off from the back of the aorta a little above the bifurcation; or (B) from one or other of the common iliacs; or (C) as a common trunk with what are usually its branches, the fifth pair of lumbar arteries. (D) It sometimes gives off an accessory renal artery—a fact of interest, in that the kidneys occupy a lower position in the abdomen in some animals than in man.

THE COMMON ILIAC ARTERIES

The **common iliac arteries** arise opposite the left side of the middle of the body of the fourth lumbar vertebra, at the bifurcation of the abdominal aorta, and, diverging from each other in the male at about an angle of 60°, and in the female at an angle of 68°, terminate opposite the lumbo-sacral articulation by bifurcating into the external iliac, which is continued along the brim of the pelvis to the lower limb, and into the hypogastric (internal iliac), which passes over the brim of the pelvis and descends into that cavity. Both arteries lie on the fifth lumbar vertebra.

The relations differ slightly on the two sides, and may be considered separately.

FIG. 452.—THE RELATIONS OF THE COMMON ILIAC ARTERIES. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Internal jugular vein
Thyreoidea ima vein
Subclavian vein
Right innominate vein
Thymic veins
Superior vena cava
Hepatic veins
Cœliac artery
Suprarenal gland
Superior mesenteric artery
Inferior vena cava
Spermatic vein
Internal spermatic artery
Common iliac artery and vein
Anterior sacral plexus
Deep circumflex iliac artery and vein
Inferior epigastric artery and vein
External spermatic artery
Femoral artery
Femoral vein
External pudendal veins
Anterior scrotal veins
Common tunica vaginalis
Thyreoid gland
Left innominate vein
Internal mammary artery and vein
Arch of aorta
Inferior phrenic vein
CARDIAC PART OF STOMACH
Left gastric artery
Inferior phrenic artery
Suprarenal gland
Splenic artery
SPLEEN
Splenic vein
Suprarenal vein
Renal vein
KIDNEY
Lumbar artery and vein
Inferior mesenteric artery
URETER
Common iliac artery and vein
Iliac branch of ilio-lumbar artery and vein
Hypogastric artery and vein
External iliac artery and vein
VAS DEFERENS
Superficial circumflex iliac
Pampiniform plexus
Great saphenous vein

THE RIGHT COMMON ILIAC ARTERY

The **right common iliac** measures about .5 cm. (2 in.) in length, and is rather longer than the left, in consequence of the aorta bifurcating a little to the left of the median line.

Relations.—In front it is covered by the peritoneum, and is crossed by the right ureter a little before its bifurcation, by the ovarian artery in the female, by the termination of the ileum, by the terminal branches of the superior mesenteric artery, and by branches of the sympathetic nerve descending to the hypogastric plexus.

Behind, it lies on the right common iliac vein, the end of the left common iliac vein, and the commencement of the inferior vena cava, which separate it from the fourth and fifth lumbar vertebræ and their intervening disc, the psoas muscle, and the sympathetic nerve; whilst still deeper in the groove between the fifth lumbar vertebra and the psoas are the lumbo-sacral cord, the obturator nerve, and the ilio-lumbar artery.

To the **right side** are the beginning of the inferior vena cava, the end of the right common iliac vein, and the posas muscle, which, however, is separated from the artery by the inferior vena cava at its upper part.

To the **left side** are the right common iliac vein, the termination of the left common iliac vein, and the hypogastric plexus.

THE LEFT COMMON ILIAC ARTERY

The **left common iliac artery,** 4 cm. (1¾ in.) in length, is a little shorter and thicker than the right.

Relations.—In front it is covered by the peritoneum, which separates it from the intestines, and is crossed by the ureter, the ovarian artery in the female, branches of the sympathetic nerve descending to the hypogastric plexus, the termination of the inferior mesenteric artery, the sigmoid colon, and the sigmoid meso-colon.

Behind are the lower border of the body of the fourth lumbar vertebra, the disc between the fourth and fifth lumbar vertebra, the body of the fifth lumbar vertebra, and the disc between it and the sacrum. Crossing deeply behind the artery between the fifth lumbar vertebra and the psoas, is the obturator nerve, the lumbo-sacral cord, and the ilio-lumbar artery.

To the **left side** is the psoas muscle.

To the **right side** are the left common iliac vein, the hypogastric plexus, and the middle sacral artery.

Variations in the Common Iliac Arteries

(A) The common iliac arteries may be longer or shorter than here described. They have been found as short as 1·2 cm. (½ in.), or as long as 11 cm. (4½ in.), but the usual limit is something between 3·7 and 7·5 cm. (1½ and 3 in.). This variation in the length of the vessels may depend upon the aorta bifurcating above or below the usual spot, or upon the common iliac arteries dividing higher or lower than usual. A low bifurcation of the aorta is somewhat more common than a high bifurcation, as is also the case with the common iliacs. (B) The common iliacs may be absent, the external and internal iliacs then arising together from the end of the aorta. (C) Either artery may give off a large branch, such as the ilio-lumbar, the lateral or the middle sacral, sometimes a lumbar, or occasionally an accessory renal artery.

Collateral Circulation

The **collateral circulation** after obstruction or ligature of the common iliac artery is carried on chiefly (fig. 461) by the anastomosis of the middle sacral with the lateral sacral; the internal mammary with the epigastric; the lumbar arteries of the aorta with the ilio-lumbar and deep circumflex iliac; the pubic branch of the epigastric with the pubic branch of the obturator; the posterior branches of the sacral arteries with the superior gluteal (gluteal); the superior hæmorrhoidal from the inferior mesenteric, with the hæmorrhoidal branches of the hypogastric (internal iliac) and pudic; the ovarian arteries from the aorta with the uterine branches of the hypogastric (internal iliac); and by the anastomosis across the middle line of the pubic branch of the obturator with the like vessel of the opposite side; the lateral sacral with the opposite lateral sacral; and the vesical, hæmorrhoidal, uterine, and vaginal branches of the internal iliac with the corresponding branches of the opposite hypogastric (internal iliac).

BRANCHES OF THE COMMON ILIAC ARTERY

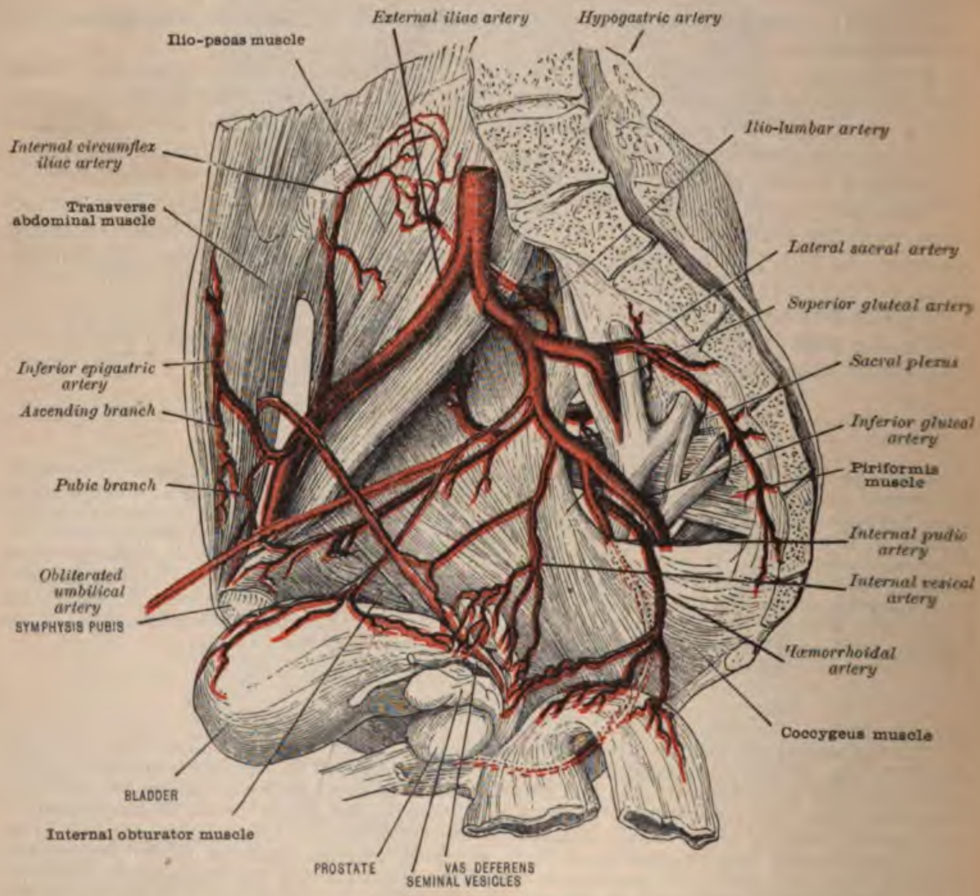
The **branches of the common iliac artery** are:—(1) The hypogastric (internal iliac); and (2) external iliac.

There are a few small, unimportant branches distributed to the peritoneum and subperitoneal fat. They anastomose with like vessels given off from the lumbar, phrenic, and renal arteries, forming a subperitoneal arterial anastomosis. The ureter receives small insignificant twigs as it crosses the artery. They anastomose with the ureteral arteries given off from the spermatic above, and with those derived from the vesical arteries below.

THE HYPOGASTRIC (INTERNAL ILIAC) ARTERY

The **hypogastric** or **internal iliac artery** arises at the bifurcation of the common iliac opposite the lumbo-sacral articulation. It descends into the pelvis for about 3 cm. (1¼ in.) and then divides, opposite the upper margin of the great sacrosciatic foramen, into an anterior and a posterior branch. The posterior branch supplies the pelvic wall and gluteal region, while the anterior branch supplies the pelvic viscera and is regarded as the continuation of the main artery.

FIG. 453.—THE HYPOGASTRIC ARTERY. (After Henle.)


External iliac artery
Hypogastric artery
Ilio-psoas muscle
Internal circumflex iliac artery
Transverse abdominal muscle
Inferior epigastric artery
Ascending branch
Pubic branch
Obliterated umbilical artery
SYMPHYSIS PUBIS
BLADDER
Internal obturator muscle
PROSTATE
VAS DEFERENS
SEMINAL VESICLES
Ilio-lumbar artery
Lateral sacral artery
Superior gluteal artery
Sacral plexus
Inferior gluteal artery
Piriformis muscle
Internal pudic artery
Internal vesical artery
Hæmorrhoidal artery
Coccygeus muscle

Relations.—Behind, it rests on the termination of the external iliac vein, the hypogastric (internal iliac) vein, the inner margin of the psoas muscle, the lumbo-sacral cord, the obturator nerve, and the sacrum.

In front, it is covered by the peritoneum, and is crossed by the ureter.

In the adult the hypogastric (internal iliac) is smaller than the external iliac; but in the fœtus it is much larger, and is the vessel by which the blood is returned to the placenta. In early fœtal life it does not descend into the pelvis, but courses above the pelvic brim by the side of the allantois, and later by the side of the bladder and urachus, to the umbilicus. At the umbilicus it is joined by the umbilical vein, and by the hypogastric artery of the opposite side. The two arteries, now known as the umbilical, coil spirally around the vein on their way to the placenta, lying in the umbilical cord (fig. 397). After birth the hypogastric artery ceases to be pervious beyond the superior vesical branch, and is converted into a fibrous cord, the obliterated hypogastric artery.

Variations.—(A) The **hypogastric (internal iliac)** may be longer or shorter than usual. It is seldom less than 2·5 cm. (1 in.) in length, but has been met with as short as 1·2 cm. (½ in.), and as long as 7·5 cm. (3 in.). The variation in length generally depends upon the length of the common iliac; when this bifurcates higher than usual, the internal iliac is then longer, and may lie at first above the brim of the pelvis; but the length may also depend upon the artery itself dividing higher or lower than usual into its branches. This division may occur anywhere between the brim of the pelvis and the upper border of the sacro-sciatic foramen. (B) Its branches may be given off without the artery dividing into an anterior and a posterior division, or one or more branches may arise above the division.

The **branches of the posterior division of the internal iliac** are all **parietal.** They are:—(1) The ilio-lumbar; (2) the lateral sacral; and (3) the superior and inferior gluteal.

The **branches of the anterior division** are for the most part **visceral.** They are:—(1) The umbilical; (2) the inferior vesical; (3) the middle hæmorrhoidal; (4) the uterine; (5) the vaginal; (6) the obturator; and (7) the internal pudic.

Branches of the Posterior Division of the Internal Iliac Artery

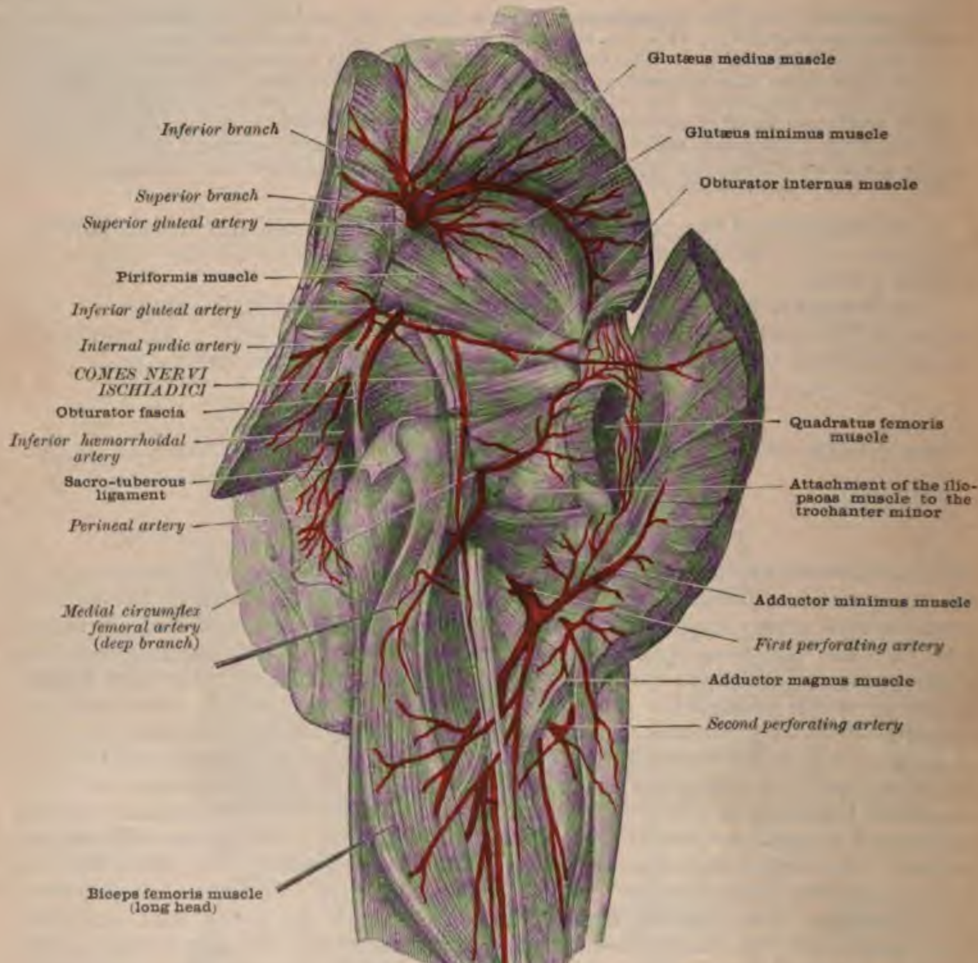
1. THE ILIO-LUMBAR ARTERY

The **ilio-lumbar artery**—a short vessel coming off from the posterior part of the hypogastric (internal iliac) artery—runs upwards and outwards beneath the common iliac artery, first between the lumbo-sacral cord and obturator nerve, and then between the psoas muscle and the vertebral column. On reaching the brim of the pelvis it divides into two branches, an iliac and a lumbar. The **iliac branch** passes outwards beneath the psoas and the femoral (anterior crural) nerve and, perforating the iliacus, ramifies in the iliac fossa between that muscle and the bone. It supplies a nutrient artery to the bone, and then breaks up into several branches which radiate from the parent trunk, upwards towards the sacro-iliac synchondrosis, outwards towards the crest of the ilium, downwards towards the anterior superior spine, and inwards towards the pelvic cavity. The first anastomoses with the last lumbar; the second with the external circumflex and gluteal; the third with the deep circumflex iliac from the external iliac; the fourth with the iliac branch of the obturator. The **lumbar branch** ascends beneath the psoas, and, supplying that muscle and the quadratus lumborum, anastomoses with the last lumbar artery. It sends a **spinal branch** into the spinal canal through the intervertebral foramen between the last lumbar vertebra and the sacrum; this branch anastomoses with the other spinal arteries. The ilio-lumbar artery is serially homologous with the lumbar arteries. Hence the similarity in its course and distribution.

2. THE LATERAL SACRAL ARTERIES

The **lateral sacral arteries,** usually two in number, arise from the posterior division of the internal iliac. The **superior artery,** when two are present, runs downwards and inwards to the first anterior sacral foramen, through which it passes; and, after supplying the spinal membranes and anastomosing with the other spinal arteries, passes through the first posterior sacral foramen, and is distributed to the skin over the back of the sacrum, there anastomosing with branches of the gluteal and sciatic arteries. The **inferior lateral sacral** descends on the side of the sacrum, external to the sacral chain of the sympathetic, and internal to the anterior sacral foramina, crossing in its course the slips of origin of the piriformis muscle and the first anterior sacral nerve. On reaching the coccyx it anastomoses in front of that bone with the middle sacral artery, and with the inferior lateral sacral of the opposite side. In this course it gives off:—**Spinal branches,** which enter the second, third, and fourth anterior sacral foramina, and, after supplying the spinal membranes and anastomosing with each other, leave the spinal canal by the corresponding posterior sacral foramina, and are distributed to the muscle and skin over the back of the sacrum; **rectal branches** which run forward to the rectum; **external branches** which are distributed to the piriformis, coccygeus, and the sacral nerves; and **internal branches** which pass inwards across the sacrum to anastomose with branches of the middle sacral artery.

FIG. 454.—THE GLUTEAL ARTERIES. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Glutæus medius muscle
Inferior branch
Glutæus minimus muscle
Obturator internus muscle
Superior branch
Superior gluteal artery
Piriformis muscle
Inferior gluteal artery
Internal pudic artery
COMES NERVI ISCHIADICI
Obturator fascia
Quadratus femoris muscle
Inferior hæmorrhoidal artery
Sacro-tuberous ligament
Attachment of the ilio-psoas muscle to the trochanter minor
Perineal artery
Adductor minimus muscle
Medial circumflex femoral artery (deep branch)
First perforating artery
Adductor magnus muscle
Second perforating artery
Biceps femoris muscle (long head)

At times the lateral sacral arteries are exceedingly small, the spinal branches then coming chiefly from the middle sacral. The anastomosing branches between the lateral sacral and middle sacral are usually regarded as sacral arteries diminished in size, and serially homologous with the lumbar and intercostal arteries.

3. THE GLUTEAL ARTERIES

There are two gluteal arteries, the **superior** and **inferior.** The **superior gluteal artery,** the largest branch of the posterior division of the hypogastric (internal iliac), comes off as a short, thick trunk from the outer and back part of that vessel, of which indeed it may be regarded as the continuation. Passing backwards between the first sacral nerve and the lumbo-sacral cord through an osseo-tendinous arch formed by the margin of the bone and the upper edge of the pelvic fascia, it leaves the pelvis through the great sacro-sciatic foramen above the piriformis muscle in company with its vein and the superior gluteal nerve. At its exit posteriorly from the great sciatic foramen it lies under cover of the gluteus maximus and beneath the superior gluteal vein, and in front of the superior gluteal nerve. It here breaks up into two chief branches, a superficial and a deep. Its emergence from the pelvis is indicated on the surface by a point situated at the junction of the posterior with the middle third of a line drawn from the anterior superior to the posterior superior spine of the ilium.

Branches of the gluteal artery:—

(*a*) **Within the pelvis,** branches are distributed to the obturator internus, the piriformis, the levator ani, the coccygeus, and the pelvic bones.

(*b*) **External to the pelvis,** the artery divides into a superior and an inferior branch.

(i) The **superior branch** breaks up into a number of large vessels for the supply of the upper portion of the gluteus maximus, some of them piercing the muscle and supplying the skin over it, and anastomosing with the posterior branches of the lateral sacral arteries; whilst one of larger size, emerging from the muscle near the iliac crest, anastomoses with the deep circumflex iliac artery. The lower branches to the muscle anastomose with branches of the inferior gluteal (sciatic).

(ii) The **inferior branch** subdivides into two branches—(*α*) One skirts along the line of origin of the gluteus minimus (fig. 454), between the gluteus medius and the bone, and, emerging in front from beneath these muscles under cover of the tensor fasciæ latæ, anastomoses with the ascending branch of the external circumflex and the deep circumflex iliac arteries. (*β*) The other passes forwards between the gluteus medius and minimus, accompanied by the branch to the tensor fasciæ latæ of the inferior division of the superior gluteal nerve, towards the great trochanter, where it anastomoses with the ascending branch of the external circumflex. It supplies branches to the contiguous muscles and to the hip-joint. The inferior branch before its division gives off the external nutrient artery of the ilium.

The **inferior gluteal** or **sciatic** artery is sometimes described as a terminal branch of the anterior division of the hypogastric artery. It leaves the pelvis below the piriformis muscle, and immediately breaks up into a number of diverging branches. The largest enter the gluteus maximus muscle, where they anastomose with the superior gluteal branches. Others pass outwards to the hip-joint and the deep muscles around it; a third group passes downwards to the muscles of the leg, while a fourth slender branch, the **comes nervi ischiadici,** accompanies the sciatic nerve.

BRANCHES OF THE ANTERIOR DIVISION OF THE HYPOGASTRIC (INTERNAL ILIAC) ARTERY

1. THE UMBILICAL ARTERY

The **umbilical artery** in the fœtus is the continuation of the hypogastric (internal iliac). Passing forwards along the side of the pelvis, it enters the lateral false ligament of the bladder, where, after giving off one or more vesical branches, it ceases to be pervious as it passes on to the side and upper part of the bladder. Thence it ascends, under cover of the anterior false ligament, as a fibrous cord, to the umbilicus, where it is joined by its fellow of the opposite side. As it lies in the lateral false (peritoneal) ligament it is crossed by the vas deferens.

2. THE VESICAL ARTERIES

The **vesical arteries** are divided into the superior, middle, and inferior.

(1) The **superior vesical artery** is a branch of the unobliterated portion of the fœtal hypogastric artery. It ramifies over the upper fundus of the bladder, anastomosing with the artery of the opposite side and with the middle and inferior vesical below. It gives off the following branches:—(*a*) The **deferential,** or **artery of the vas deferens,** arises from the superior vesical near the spot where the vas crosses the obliterated hypogastric artery, and, having reached the vas, divides into an ascending and a descending branch. The ascending branch follows the vas through the inguinal canal to the testis, where it anastomoses with the spermatic artery. The descending branch passes downwards to the dilated portion of the vas and vesiculæ seminales. (*b*) The **urachal branch** passes upwards along the urachus. (*c*) The **ureteric branches** pass to the lower end of the ureter, which they supply, and anastomose with the other ureteric arteries. (*d*) The **middle vesical** (sometimes).

(2) The **middle vesical** is a branch either of the superior vesical, or of the unobliterated portion of the hypogastric artery. In the latter case it is given off before the superior vesical. It is distributed to the sides and base of the bladder, and anastomoses with the other vesical arteries.

(3) The **inferior vesical** arises from the anterior division of the hypogastric (internal iliac), frequently in common with the middle hæmorrhoidal, and passes downwards and inwards to the base of the bladder, where it breaks up into branches which ramify over the lower part of the viscus. It gives off:—(*a*) Branches to the prostate, which supply that organ and anastomose with the arteries of the opposite side by means of descending arteries which pass through the prostatic plexus of veins, but outside the capsule of the prostate, and with the inferior hæmorrhoidal branches of the internal pudic. At times one of these prostatic branches is of large size, and supplies certain of the parts normally supplied by the internal pudic. It is then known as the **accessory pudic,** and then most commonly terminates as the dorsal artery of the penis. (*b*) Branches to the vesiculæ seminales; and (*c*) branches (in the female) to the vagina. (See VAGINAL ARTERY.) The artery of the vas deferens sometimes arises from the inferior vesical instead of from the superior vesical.

3. THE MIDDLE HÆMORRHOIDAL ARTERY

The **middle hæmorrhoidal,** variable in its origin, perhaps most commonly arises from the anterior division of the internal iliac along with the inferior vesical. It runs inwards to the sides of the middle portion of the rectum, dividing into branches which anastomose above with the superior hæmorrhoidal derived from the inferior mesenteric, and below with the inferior hæmorrhoidal derived from branches of the pudic. Its corresponding vein terminates in the inferior mesenteric vein. In the female it also sends branches to the vagina.

4. THE UTERINE ARTERY

The **uterine artery** arises from the anterior branch of the hypogastric (internal iliac) close to or in conjunction with the middle hæmorrhoidal or inferior vesical. It runs downwards and inwards through the pelvic connective tissue, crossing the ureter about 12 mm. (½ in.) from the cervix uteri. It then turns upwards and ascends in the parametrium between the layers of the broad ligament at the side of the uterus in a coiled and tortuous manner, and, after giving off a number of tortuous branches which ramify in a horizontal manner over the front and back of the uterus, supplying its substance, anastomoses with the uterine branch of the ovarian artery. In addition to the branches to the uterus the **branches of the uterine artery** are:—(1) **Cervical.**—This branch comes off from the uterine as the latter artery crosses the ureter to turn upwards on to the uterus. It runs directly inwards, and divides into three or four branches which pass on to the cervix at right angles to it; one branch anastomosing with its fellow of the opposite side in front and behind the neck, forming the so-called coronary artery of the cervix. (2) **Tubar.**—This courses along the lower surface of the tuba uterina (Fallopian tube) as far as its fimbriated extremity, and may also send a branch to the ligamentum teres. (3) **Ovarian.**—This runs along the attached border of the ovary, sending branches to that structure, and terminates by anastomosing widely with the ovarian artery. Occasionally the vaginal artery also arises from the uterine.

5. THE VAGINAL ARTERY

The **vaginal artery** corresponds to the inferior vesical artery of the male, and arises either directly from the inner wall of the hypogastric (internal iliac) artery, close to the origin of the uterine, or else from a common stem with the latter vessel.

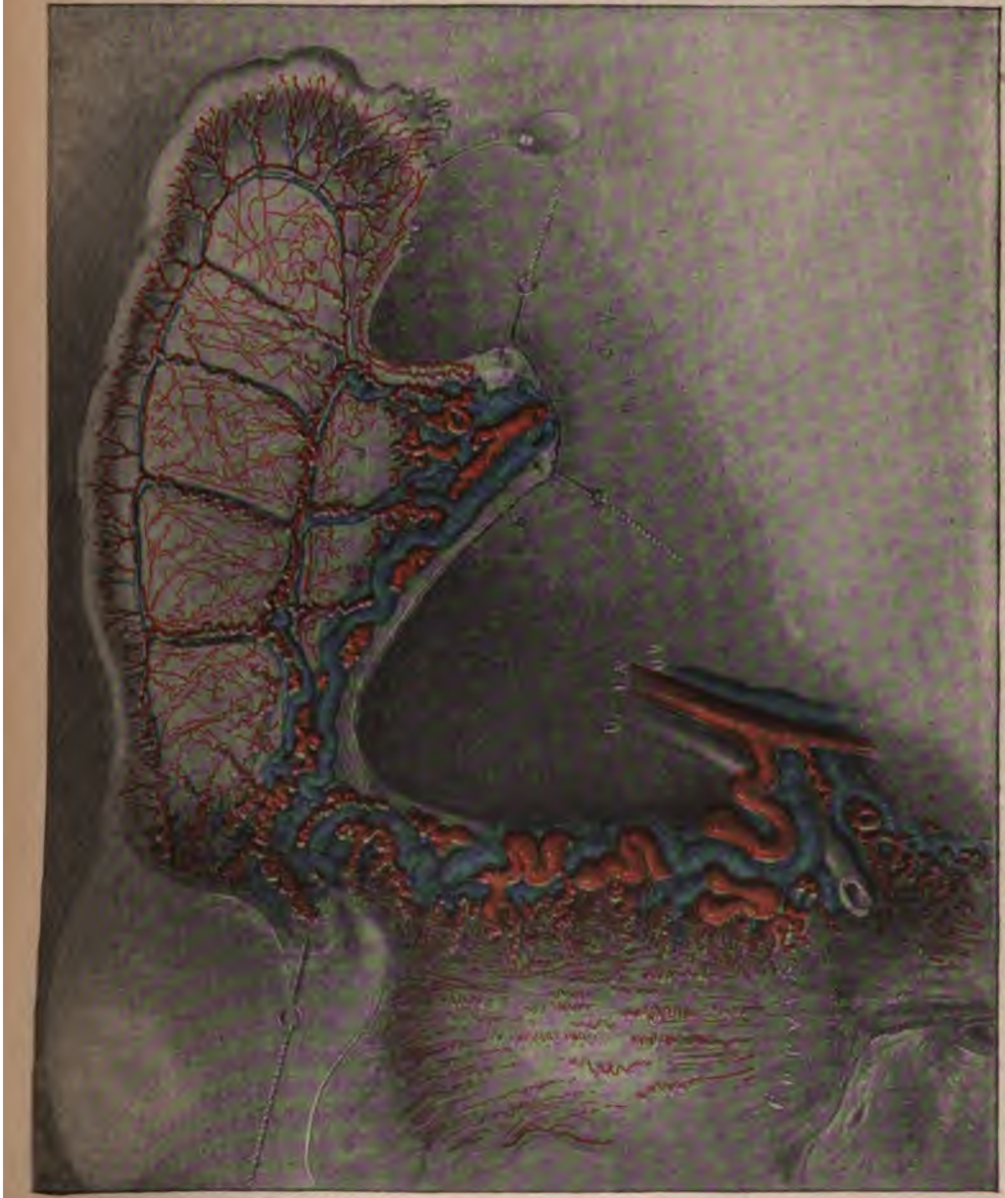


Fig. 455.—Scheme of the Ovarian and Uterine and Vaginal Arteries. (From Kelly, by Brödel.)

It passes medially, behind the ureter, to the upper part of the vagina, and sends numerous branches to that structure and also some to the posterior part of the base of the bladder.

The branches to the vagina tend to anastomose with one another and with the cervical branch of the uterine, to form a more or less perfect vertical stem in the median line of the vagina, both back and front. This stem is sometimes termed the **azygos artery of the vagina**. Branches also pass to the vagina from the middle hæmorrhoidal artery.

6. THE OBTURATOR ARTERY

The **obturator artery** arises either from the anterior or the posterior division of the hypogastric (internal iliac). It runs forwards and downwards a little below the brim of the pelvis, having the obturator nerve above and the obturator vein below. It here lies between the peritoneum and the pelvic fascia, but later it passes through the obturator canal, the aperture in the upper and outer part of the obturator membrane. In this course it is crossed by the vas deferens. On emerging from the obturator canal the artery divides into two branches, an external and an internal, which wind around the margin of the obturator foramen beneath the obturator externus muscle.

Within the pelvis the artery gives off:—(1) An iliac or nutrient branch; (2) a vesical branch; and (3) a pubic branch. Without the pelvis, it divides into:—(1) An external branch; and (2) an internal branch.

A. *Intra-pelvic branches.*—(1) The **iliac** or **nutrient branch** ascends to the iliac fossa, passing between the iliacus muscle and the bone. It supplies a nutrient vessel to the ilium, and anastomoses with the internal branch of the iliac division of the ilio-lumbar artery.

(2) The **vesical branch** or branches are small vessels which run in the lateral false ligament of the bladder to that organ, where they anastomose with the other vesical arteries.

(3) The **pubic branch** comes off from the obturator as that vessel is leaving the pelvis by the obturator canal. It runs upwards and inwards behind the pubis, anastomosing with its fellow of the opposite side of the body, and with the pubic branch of the deep epigastric artery. One of the anastomosing channels between the pubic branch of the obturator and pubic branch of the deep epigastric arteries is sometimes of large size, a fact of surgical interest in that the enlarged vessel may then run around the inner side of the femoral ring (p. 614).

B. *Extra-pelvic branches.*—(1) The **external branch** skirts the external margin of the obturator foramen, lying between the obturator externus and the obturator membrane. At the lower margin of the foramen it divides into two branches. One branch continues its course around the lower margin of the foramen, and anastomoses with the internal branch of the obturator and with the internal circumflex. The other branch turns outwards below the acetabulum, and ends in the muscles arising from the tuberosity of the ischium. It anastomoses with the inferior gluteal (sciatic) artery. This branch gives off a small twig, the **acetabular artery**, which passes under the transverse ligament into the hip-joint, where it supplies the synovial membrane, the ligamentum teres, and the fat in the fossa at the bottom of the acetabulum.

(2) The **internal branch** runs around the inner margin of the obturator foramen, and anastomoses with the inner division of the external branch and with the internal circumflex artery. It supplies branches to the obturator and adductor muscles.

7. THE INTERNAL PUDIC ARTERY

The **internal pudic artery** arises opposite the piriformis muscle. It descends with the inferior gluteal (sciatic) over the piriformis and sacral plexus of nerves, lying anterior and internal to the latter artery as far as the lower border of the great sciatic foramen, where it passes out of the pelvis between the piriformis and coccygeus muscles. It then winds over the outer surface of the spine of the ischium under cover of the gluteus maximus, and enters the ischio-rectal fossa through the lesser sciatic notch. Running forwards over the obturator internus muscle, it passes through the base of the urogenital trigone (triangular ligament), and, continuing its course along the ramus of the pubis, between the two layers of the trigone, it passes through the anterior layer of the trigone as the artery of the penis.

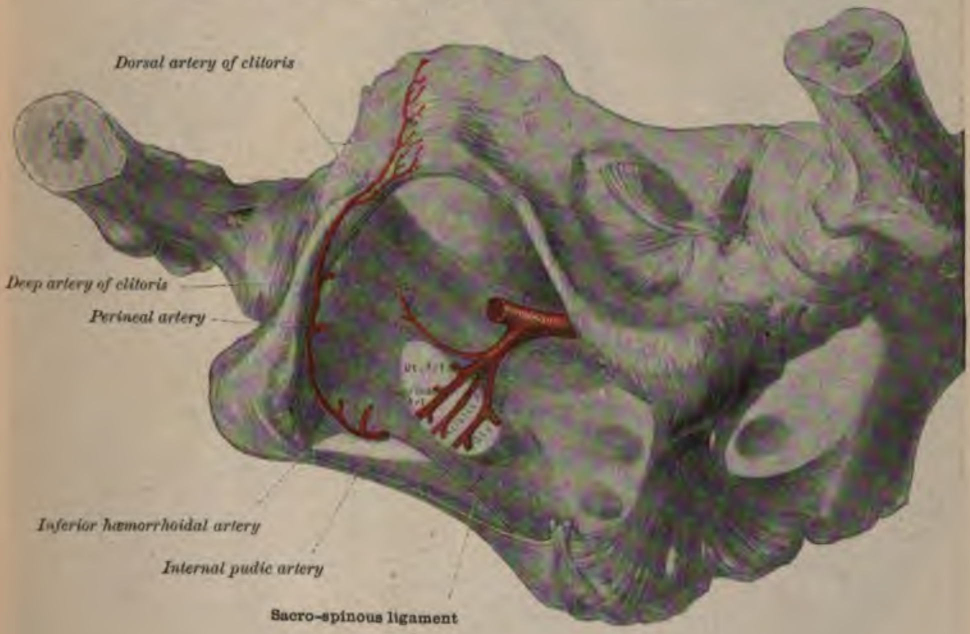
The **relations of the artery** may be considered:—(1) As it lies within the pelvis;

(2) as it crosses the spine of the ischium; (3) as it lies on the obturator internus muscle, in the outer wall of the ischio-rectal fossa; and (4) as it lies between the two layers of the uro-genital trigone.

(1) **Within the pelvis** the artery crosses the piriformis muscle and sacral plexus of nerves, lying somewhat anterior and internal to the inferior gluteal (sciatic) artery, which is usually given off from the hypogastric (internal iliac) along with it. At the lower border of the sciatic foramen it leaves the pelvis by passing between the piriformis and coccygeus muscles along with the inferior gluteal (sciatic) artery, the pudic nerve, the sciatic and posterior femoral cutaneous (lesser sciatic) nerves and the nerve to the obturator internus.

(2) **As it crosses the spine of the ischium** it has a companion vein on either side, the pudic nerve on its inner side, and the nerve to the obturator internus on its outer side. It is covered by the gluteus maximus muscle, and more or less by the overlapping edge of the sacro-tuberous (great sacro-sciatic) ligament. In a thin subject it can be felt pulsating as it crosses the ischial spine. A spot taken at the junction of the inner with the outer two-thirds of a line drawn from the top of the great trochanter with the femur rotated inwards to the base of the coccyx, indicates externally the situation of the artery as it crosses the ischial spine. In this situation it may, in a thin subject, be compressed. The **branches of the artery** in this part of its course are:—(*a*) Small twigs to the gluteus maximus; (*b*) a small branch to the obturator internus which accompanies the nerve to that muscle; (*c*) a sacral branch which pierces the sacro-tuberous (great sacro-sciatic) ligament and anastomoses with the inferior gluteal (sciatic) artery.

FIG. 456.—THE INTERNAL PUDIC ARTERY. (From Kelly, by Brödel.)

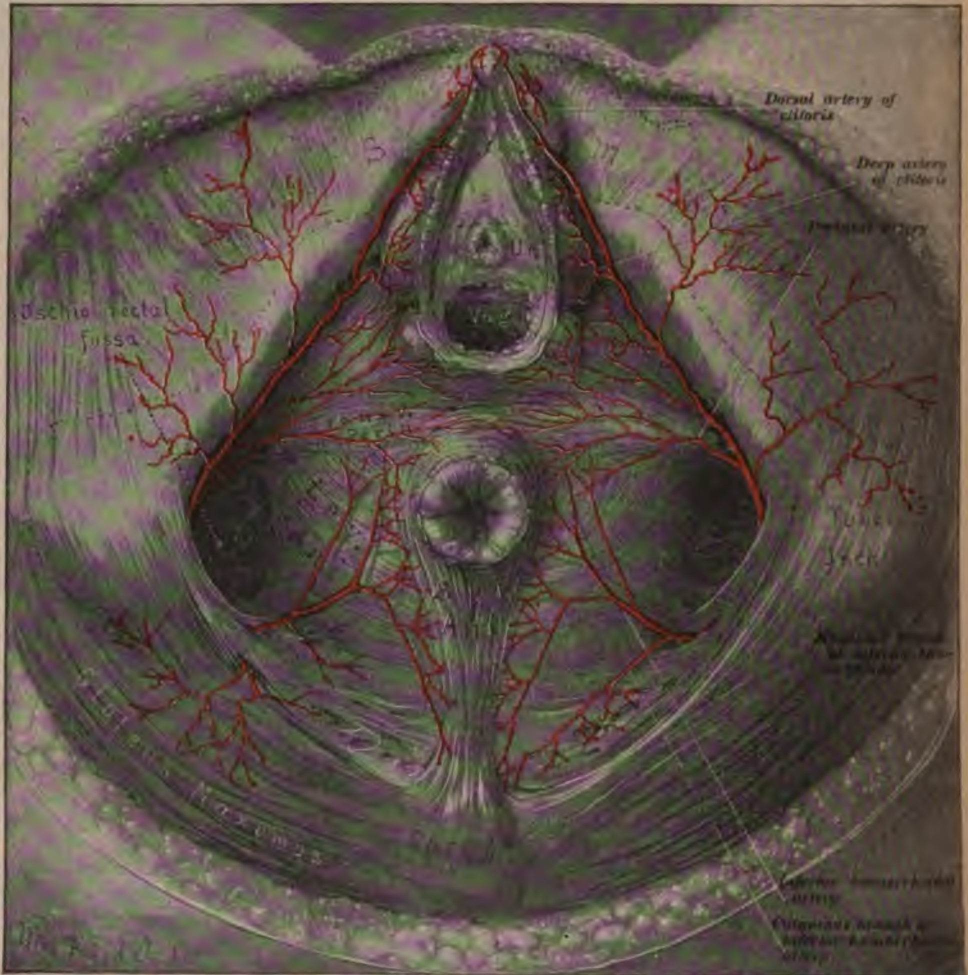

Dorsal artery of clitoris
Deep artery of clitoris
Perineal artery
Inferior hæmorrhoidal artery
Internal pudic artery
Sacro-spinous ligament

(3) In the **third part of its course,** as it lies on the obturator internus muscle, in the outer wall of the ischio-rectal fossa, it is placed about 3·5 cm. (1½ in.) above the lower margin of the tuberosity of the ischium. It is here bound down to the muscle by a strong sheath of the obturator layer of the pelvic fascia (Alcock's canal). In this part of its course the dorsal nerve of the penis and the superficial perinæal nerve, into which the pudic nerve divides about this situation, lie respectively above and below the artery.

The **branches of the pudic artery** in the third part of its course are:—(*a*) The inferior hæmorrhoidal; and (*b*) the perinæal.

(*a*) The **inferior hæmorrhoidal branches** are given off from the pudic at the posterior part of the ischio-rectal fossa, just after it enters the outer wall of that cavity through the lesser sciatic foramen. They perforate the sheath of obturator fascia binding the pudic artery to the obturator internus, and course transversely through the fat of the ischio-rectal fossa, inwards to the anus, where they supply the sphincter muscle and levator ani, and anastomose with the superior and middle hæmorrhoidal arteries. Twigs are given off from them to the skin covering the anal triangle of the perinæum; other branches supply the gluteus maximus and wind over the posterior fold of that muscle to the integuments; whilst others again run forwards and anastomose with the perinæal arteries (fig. 457).

Fig. 457.—The Arteries of the Perinæum. (From Kelly, by Brödel.)



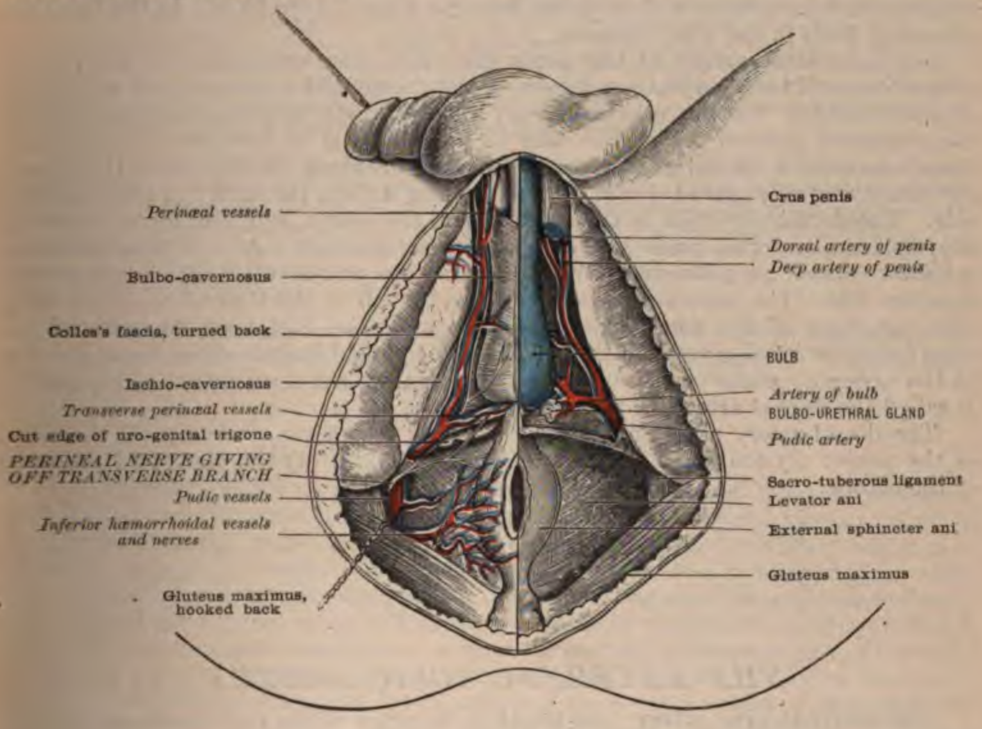
(*b*) The **perinæal branch** arises from the pudic at the front of the ischio-rectal fossa, just before that vessel pierces the posterior layer of the uro-genital trigone (triangular ligament). It passes through the superficial fascia of the perinæum (Colles's fascia), where that structure is continued into the anterior layer of the uro-genital trigone around the transverse perinæal muscle. It then crosses in front of (occasionally behind) that muscle, and enters the superficial perinæal interspace, the space between Colles's fascia and the superficial layer of the uro-genital trigone, bounded by the ischio-cavernosus externally, the bulbo-cavernosus internally, and the superficial transverse perinæal muscle behind. On nearing the apex of this triangle it divides into long slender branches, which are continued along the back of the scrotum, anastomosing with the superficial external pudic branch of the common femoral. In this course it is accompanied by the perinæal nerve. It supplies the contiguous muscles and the integuments of the scrotum. As a rule it gives off the following branch:—

The **transverse perinæal artery** usually arises from the before-mentioned artery. Occasionally it is a direct branch from the pudic trunk. It courses transversely inwards, on the superficial transverse perinæal muscle, towards the central tendon of the perinæum, supplying the muscles and integuments of the perinæum, and anastomosing with its fellow of the opposite side.

(4) In the **fourth part of its course** the pudic artery lies between the two layers of the uro-genital trigone, close to the ramus of the pubis, in the substance of the sphincter of the membranous urethra, having the superficial layer of the uro-genital trigone (triangular ligament) in front and the deep layer behind. In this situation it gives off the artery of the urethral bulb, the artery of the urethra, and the deep artery of the penis, and then continues its course forwards through the superficial layer of the uro-genital trigone under the name of the dorsal artery of the penis.

FIG. 458.—THE ARTERIES OF THE PERINÆUM.

On the right side Colles's fascia has been turned back to show the superficial vessels. On the left side the superficial vessels have been cut away with the anterior layer of the uro-genital trigone to show the deep vessels.


Perinæal vessels
Bulbo-cavernosus
Colles's fascia, turned back
Ischio-cavernosus
Transverse perinæal vessels
Cut edge of uro-genital trigone
PERINEAL NERVE GIVING OFF TRANSVERSE BRANCH
Pudic vessels
Inferior hæmorrhoidal vessels and nerves
Gluteus maximus, hooked back
Crus penis
Dorsal artery of penis
Deep artery of penis
BULB
Artery of bulb
BULBO-URETHRAL GLAND
Pudic artery
Sacro-tuberous ligament
Levator ani
External sphincter ani
Gluteus maximus

(*a*) The **artery of the urethral bulb,** often of large size, comes off from the pudic soon after or even before that vessel has passed between the two layers of the uro-genital trigone. It runs inwards and slightly upwards behind the superficial layer of the uro-genital trigone, embedded more or less in the substance of the sphincter of the membranous urethra. On nearing the urethra it passes forwards through a hole in the superficial layer of the uro-genital trigone, by the side of the opening for the urethra, and, entering the bulb, supplies the erectile tissue of the bulb and corpus spongiosum in the way described under the anatomy of the urethra. It gives off a branch, just before piercing the anterior layer of the uro-genital trigone, to the bulbo-urethral (Cowper's) glands (fig. 458).

The situation of the artery of the bulb should be remembered in performing the operation of lateral lithotomy. As a rule, the artery is well above the central tendon of the perinæum. At times, however, the artery is given off from the pudic lower than normal. Its division may then be unavoidable.

When the artery is given off, as it occasionally is, from the accessory pudic, it pierces the superficial layer of the uro-genital trigone higher up, and is out of danger in the ordinary low operation of lateral lithotomy. Further, the artery of the bulb may be absent on one side, smaller than usual, or double. **In the female,** the artery of the bulb, smaller than in the male, ends in the bulb of the vestibule.

(*b*) The **urethral** artery is a small branch, sometimes given off by the deep artery of the penis, which passes to the corpus spongiosum of the urethra and anastomoses with branches of the artery of the bulb.

(*c*) The **deep artery of the penis** is usually given off from the pudic a little higher than the artery of the bulb. It makes at once for the ramus of the pubis, perforates the superficial layer of the uro-genital trigone close to the bone, and enters the crus penis (fig. 458). This artery has to be divided in the operation for the removal of the whole of the penis by dissecting off the crura from the rami of the pubis and ischium. Its situation close to the bone at times gives rise to some little trouble in securing it. A small additional artery to the corpus spongiosum is occasionally given off from this branch and then contributes to the supply of that structure and inosculates with branches from the artery to the bulb. **In the female,** the artery ends in the crus clitoridis.

(*d*) The **dorsal artery of the penis** (fig. 458), the termination of the pudic, passes forwards between the two layers of the uro-genital trigone in the substance of the sphincter urethræ membranaceæ; then, turning downwards, it perforates the superficial layer of the trigone near its apex, a little to one side of the central apical opening for the dorsal vein. It then descends along the dorsum of the penis, the single centrally placed dorsal vein separating it from the artery of the opposite side. The dorsal nerve lies to the outer side of the artery, and, still more external, the superficial external pudic branch of the femoral artery. At the glans the dorsal artery forms an anastomotic chain around the corona with the vessel of the opposite side. The superficial external pudic branch of the femoral at times may take the place of the dorsal artery. Occasionally the dorsal artery is found to arise from the inferior vesical; that is, from an enlarged branch of the vessel known as the accessory pudic (see p. 606). **In the female,** the termination of the pudic is called the **dorsal artery of the clitoris.**

The dorsal artery gives branches to—(*a*) The corpus cavernosum; (*b*) the skin of the penis; (*c*) the glans penis; and **in the female,** (*d*) the glans and prepuce of the clitoris.

THE EXTERNAL ILIAC ARTERY

The **external iliac artery**—the larger in the adult of the two vessels into which the common iliac divides opposite the lumbo-sacral articulation—extends from this spot along the brim of the pelvis, lying upon the inner border of the psoas muscle, to the lower margin of Poupart's ligament, where, midway between the anterior superior spine of the ilium and the symphysis pubis, it passes into the thigh, and takes the name of the femoral.

It measures 8·5 to 10 cm. (3½ to 4 in.) in length. The course of the vessel is indicated by a line drawn from 1·2 cm. (½ in.) below and a little to the left of the umbilicus, to a point a little internal to the centre of Poupart's ligament, that is, to a spot midway between the symphysis pubis and the anterior superior spine of the ilium. If this line is divided into thirds, the lower two-thirds indicate the situation of the external iliac, the upper third the common iliac. The external iliac vein, the continuation upwards of the femoral vein from the thigh, lies to the inner side of the artery, but on a slightly lower plane, and, just before its termination, gets a little behind the artery on the right side.

Relations.—In front, the artery together with the vein is covered by the parietal peritoneum descending from the abdomen into the pelvis, and by a layer of condensed subperitoneal tissue, known as Abernethy's fascia. It is crossed by the termination of the ileum on the right side, and by the sigmoid colon on the left. The external spermatic (genital) branch of the genito-femoral (genito-crural) nerve runs obliquely over its lower third, and just before its termination it is crossed transversely by the deep circumflex iliac vein. The spermatic vessels lie for a short distance on the lower part of the artery, and the vas deferens in the male and the ovarian vessels in the female curve over it to descend to the pelvis. It is sometimes crossed at its origin by the ureter. The external iliac lymphatic nodes lie along the course of the artery. The commencement of its inferior epigastric branch is also in front.

Behind.—At first the artery lies partly upon its own vein; lower down upon the inner border of the psoas; and just before it passes through the lacuna vasorum, beneath Poupart's ligament, upon the tendon of the psoas. The continuation of the iliac into the pelvic fascia is also below it.

To its **inner side** is the external iliac vein, the peritoneum, the descending layer of fascia, and the vas deferens in the male, and ovarian vessels in the female.

To its **outer side** is the psoas muscle and the iliac fascia.

Variations.—(A) The external iliac may be longer or shorter than usual, according as the common iliac bifurcates above or below the usual spot. When longer it often takes a very tortuous course, making a partial loop or bend which may dip down below the brim of the pelvis. (B) It may be much smaller in size than usual; this is especially the case in those instances in which the femoral or main vessel of the lower limb arises from the inferior gluteal or other branch of the hypogastric. It then often ends in the profunda. (C) It may give off a large branch, as the deep circumflex iliac or deep epigastric, higher than usual.

The **collateral circulation** is carried on (fig. 461) when the external iliac is tied, by the anastomosis of the ilio-lumbar and lumbar arteries with the circumflex iliac; the internal mammary with the deep epigastric; the obturator with the internal circumflex; the inferior gluteal with the internal circumflex and superior perforating; the gluteal with the external circumflex; the arteria comes nervi ischiadici from the inferior gluteal, with the perforating branches of the profunda; the external pudic with the internal pudic; the pubic branch of the obturator with the pubic branch of the epigastric.

The **branches of the external iliac artery** are:—(1) The inferior epigastric; (2) the deep circumflex iliac; and (3) several small and insignificant twigs to the neighbouring psoas muscle and lymphatic glands.

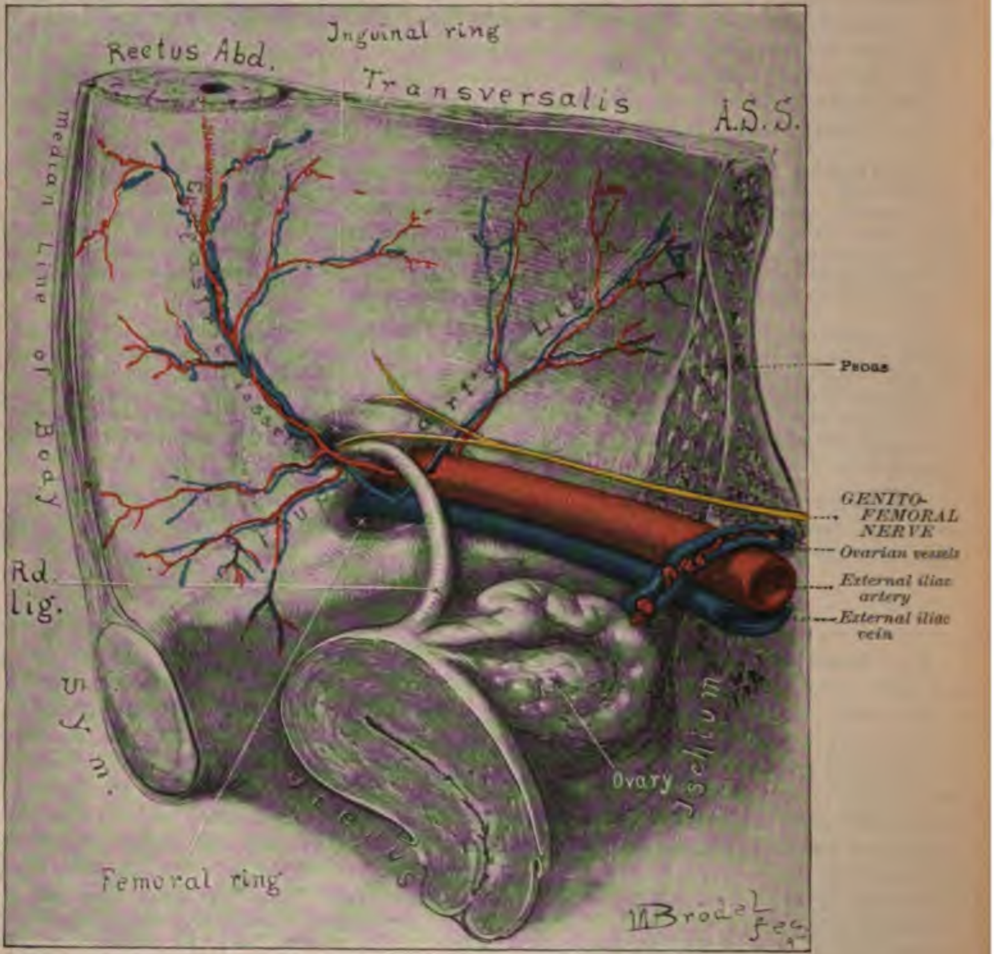
(1) The Inferior Epigastric Artery

The **inferior** or **deep epigastric artery** usually comes off from the external iliac just above Poupart's ligament. Immediately after its origin, the vas deferens in the male, and the round ligament in the female, loop around it on their way to the pelvis, drawing, as it were, the artery slightly inwards and downwards. It here lies internal to the inner margin of the abdominal inguinal (internal abdominal) ring, behind the inguinal canal, and a little to the upper and outer side of the femoral ring. Thence it passes upwards and inwards, above and to the outer side of the subcutaneous inguinal (external abdominal) ring, lying between the fascia transversalis and the peritoneum, to the lower margin of the posterior layer of the sheath of the rectus (fold of Douglas). Having pierced the fascia transversalis at this point, it passes in front of Douglas' fold and turns upwards between the rectus and its sheath, lying here about midway between the outer and inner edge of the muscle. Higher, it enters the substance of the muscle, and anastomoses with the superior epigastric, descending in the rectus from the internal mammary.

The situation of the artery between the two inguinal rings should be borne in mind in the operation for strangulated inguinal hernia, and its near proximity to the upper and outer side of the femoral ring should not be forgotten in the operation for femoral hernia. The artery is accompanied by two veins, of which the inner is the larger. They end in a single trunk before opening into the external iliac vein.

The deep epigastric gives off the following small branches:—(*a*) The **external spermatic,** which runs with the vas through the inguinal canal, supplies the cremaster muscle, and anastomoses with the spermatic, inferior external pudic, and superficial perinæal arteries. (*b*) The **pubic,** which passes below, or sometimes above, the femoral ring to the back of the pubis, where it anastomoses with the pubic branch of the obturator and the corresponding vessel of the opposite side. This branch, though usually small, is occasionally considerably enlarged, when its exact course becomes of great interest to the surgeon. Thus it may descend immediately internal to the vein, and therefore external to the femoral ring, or it may pass inwards in front of the femoral ring and turn downwards either behind the os pubis or immediately behind the free edge of the lacunar (Gimbernat's) ligament, in which situation it would be exposed to injury in the operation for the relief of a strangulated femoral hernia. (*c*) The **muscular,** which supply the rectus and the oblique and transverse muscles of the abdomen, and anastomose with the lower intercostal and the lumbar arteries. (*d*) The **cutaneous,** which pierce the rectus, and supply the skin, anastomosing with branches of the superficial epigastric. And (*e*) the **terminal,** which anastomose above the umbilicus with the superior epigastric branch of the internal mammary.

FIG. 459.—THE DEEP EPIGASTRIC ARTERY. (From Kelly, by Brödel.)



Variations.—(A) The epigastric may come off from the external iliac higher than usual; it has been met with arising as much as 6·2 cm. (2½ in.) above Poupart's ligament. (B) It may arise from the femoral below Poupart's ligament, or even from the profunda. (C) It may arise as a common trunk with the circumflex iliac. (D) It is sometimes double. (E) It may arise from the obturator, or conversely it may give off the obturator artery. This variation is due to the enlargement of the normal anastomosis of the epigastric and obturator through their pubic branches. It is of considerable importance to the surgeon, since the obturator artery, when given off from the epigastric, may run either external or internal to the femoral ring to reach the obturator foramen. This abnormal origin of the obturator is said to occur once in every three subjects and a half; but the abnormal artery only courses around the inner side of the ring—in which situation it is liable to injury in the operation for femoral hernia—in exceptional cases. According to Langton (Holden's 'Anatomy'), the chances are about seventy to one against this occurring. But even when it takes the abnormal course, it lies 3 mm. or so from the margin of the ring, and will probably escape injury in the division of the stricture if several short notches are made in place of a single and longer incision.

(2) THE DEEP CIRCUMFLEX ILIAC ARTERY

The **deep circumflex iliac** arises from the outer side of the external iliac artery either opposite the epigastric or a little below the origin of that vessel. It courses upwards and outwards just above the lower margin of Poupart's ligament, lying between the fascia transversalis and the peritoneum, or at times in a fibrous canal formed by the union of the fascia transversalis with the iliac fascia. Near the anterior superior spine of the ilium, it perforates the transversalis, and then courses between that muscle and the internal oblique, along and a little above the crest of the ilium. It finally divides into an ascending branch, which anastomoses with the lumbar and lower intercostal arteries, and a marginal branch which runs backwards to anastomose with the ilio-lumbar artery. It is accompanied by two veins. These unite into one trunk, which then crosses the external iliac artery to join the external iliac vein.

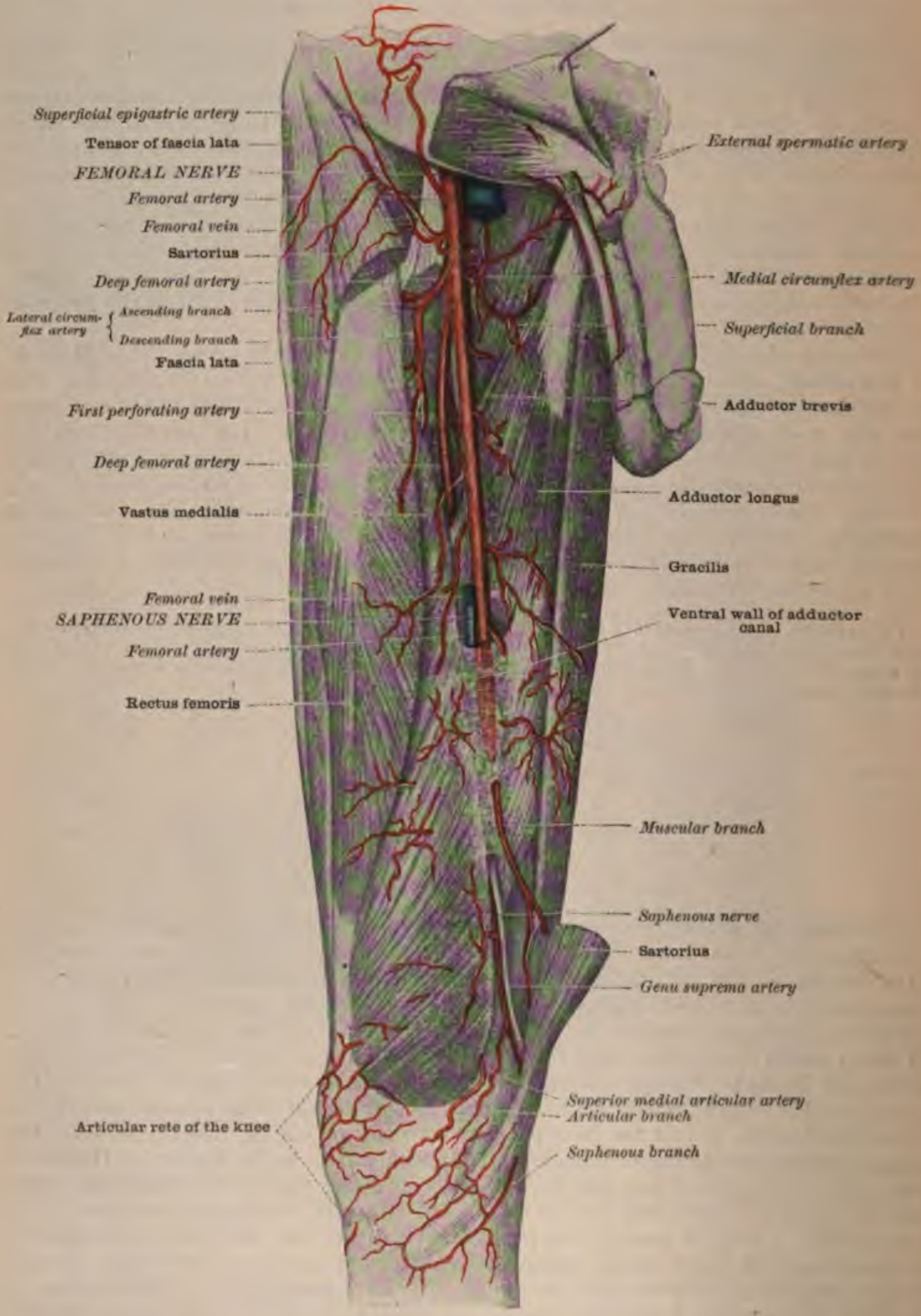
The deep circumflex iliac artery gives off the following branches:—(*a*) **Muscular branches,** which supply the psoas, iliacus, sartorius, tensor fasciæ latæ, and the oblique and transverse muscles of the abdomen. One of these branches, larger than the rest, usually arises about 2·5 cm. (1 in.) behind the anterior superior spine of the ilium and ascends perpendicularly between the transversalis muscle and the internal oblique. It has received no name but is important to the surgeon, as it indicates the intermuscular plane between the two muscles. (*b*) **Cutaneous branches,** which supply the skin over the course of the vessel, and anastomose with the superficial circumflex iliac, the superior gluteal, and the ascending branch of the external circumflex.

Variations.—(A) The **circumflex iliac,** like the epigastric, may be given off from the external iliac higher than normal, though seldom if ever as high as the latter. (B) More rarely it may come off from the femoral below Poupart's ligament. (C) It may arise as a common trunk with the epigastric. (D) It may be double.

THE FEMORAL ARTERY

The **femoral artery** (fig. 460) is the continuation of the external iliac, and extends from the lower border of Poupart's ligament, down the front and inner part of the thigh, to the tendinous opening in the adductor magnus, through which it passes into the popliteal space, and is then known as the popliteal. The femoral artery is at first quite superficial, being merely covered by the skin, and superficial and deep fascia; but, after thus passing about 13 cm. (5 in.) in a direction downwards and inwards through the space known as the femoral trigone (Scarpa's triangle), it sinks at the apex of that triangle beneath the sartorius muscle, and thence to its termination continues beneath the sartorius, coursing deeply between the vastus medialis and adductor muscles in the space known as the adductor (Hunter's) canal. It at first rests upon the brim of the pelvis and head of the thigh bone, from which it is merely separated by the capsule of the hip-joint and the tendon of the psoas. Here it can be readily compressed. Owing to the obliquity of the neck of the femur and the direct course taken by the artery, it lies lower down only on muscles, at some little distance from the bone. At its termination, in consequence of the shaft of the femur inclining towards the middle line of the body, the artery lies close to the bone, but to the inner side. The course of the vessel when the thigh is slightly flexed and abducted—the position in which the limb is placed when the vessel is ligatured—is indicated by a line drawn from a spot midway between the anterior superior spine of the ilium and the symphysis pubis to the adductor tubercle. When the thigh is in the extended position and parallel to its fellow, the course of the artery will correspond to a line drawn from the spot above mentioned to the inner border of the patella.

Fig. 460.—The Femoral Artery. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Superficial epigastric artery
Tensor of fascia lata
FEMORAL NERVE
Femoral artery
Femoral vein
Sartorius
Deep femoral artery
Lateral circumflex artery
Ascending branch
Descending branch
Fascia lata
First perforating artery
Deep femoral artery
Vastus medialis
Femoral vein
SAPHENOUS NERVE
Femoral artery
Rectus femoris
Articular rete of the knee
External spermatic artery
Medial circumflex artery
Superficial branch
Adductor brevis
Adductor longus
Gracilis
Ventral wall of adductor canal
Muscular branch
Saphenous nerve
Sartorius
Genu suprema artery
Superior medial articular artery
Articular branch
Saphenous branch

The artery for about 4 to 5 cm. (1½ to 2 in.) is known as the common femoral, but at this distance from Poupart's ligament it gives off a large branch called the profunda, or deep femoral. For the rest of its course it is known as the superficial femoral. The superficial femoral is only superficial where it lies in the femoral trigone—that is, for about 9 cm. (3½ in.) of its course; the remainder of the artery being deeply placed in the adductor canal, though less deeply than the profunda, or deep femoral. The details of the anatomy of the femoral will perhaps best be studied by considering the relations of (1) the common femoral; (2) the superficial femoral as it lies in the femoral trigone; and (3) the superficial femoral as it lies in the adductor canal.

(1) **The relations of the common femoral artery.—In front,** the common femoral (fig. 460) is covered by the skin, the superficial fascia, the iliac portion of the fascia lata, the lumbo-inguinal (crural) branch of the genito-femoral nerve, the superficial circumflex iliac vein, and sometimes the superficial epigastric vein. The fascia transversalis, which is continued downwards into the thigh beneath Poupart's ligament, is also one of its anterior relations, but soon becomes indistinguishable from the sheath of the vessel.

Behind, the artery rests upon the tendon of the psoas muscle, which separates it from the brim of the pelvis and capsule of the hip-joint, and, a little lower, on the pectineus, more or less loose fat and cellular tissue intervening. The branches of the femoral (anterior crural) nerve to the pectineus muscle also pass behind it.

A similar prolongation to that derived from the fascia transversalis in front descends behind the vessel from the iliac fascia; but, like the anterior prolongation of fascia, soon blends with the sheath of the vessels.

To the **inner side** is the femoral vein, but separated from the artery in the upper part of its course by a thin layer of fascia passing from the continuation of the iliac fascia behind the vessels, to the continuation of the fascia transversalis in front of the vessels.

To the **outer side** is the leash of nerves known as the femoral (anterior crural). These are, however, separated from the artery by a few fibres of the psoas muscle.

(2) **The relations of the superficial femoral artery in the femoral trigone (Scarpa's triangle)** (fig. 460).—**In front,** the artery is covered by the skin and by the superficial and deep fascia, and is crossed at the lower part of the trigone by a cutaneous branch of the femoral nerve. The lumbo-inguinal (crural) branch of the genito-femoral (genito-crural) nerve is superficial to it, but is separated from this part of the femoral artery by the deep fascia.

Behind, the artery lies on the pectineus, from which it is separated by the femoral vein and the profunda vein and artery. Lower down, it lies on the upper portion of the adductor longus muscle.

To its **outer side** is the saphenous nerve and the nerve to the vastus medialis, the femoral (anterior crural) nerve having in this situation more or less broken up into its components.

To its **inner side** is the femoral vein, which, however, at the apex of the femoral trigone, is getting somewhat behind the artery.

The superficial femoral varies in length according to the distance that the profunda is given off from the common femoral below Poupart's ligament. As a rule, it measures 9 cm. (3½ in.), the common 4 cm. (1½ in.). But the profunda may come off 5 cm. (2 in.) or more below Poupart's ligament, in which case the superficial femoral will be shorter to this extent; or it may come off less than 3·7 cm. (1½ in.) below Poupart's ligament, or even from the external iliac above Poupart's ligament, when the superficial will be longer than normal. The practical point to remember is that it is more usual to meet with a short than with a long common femoral, and that, if the superficial femoral is tied at the apex of the femoral trigone—i. e. the spot where the inner edge of the sartorius comes into contact with the adductor longus—there is nearly always a sufficient length of that vessel above the ligature to ensure a firm internal clot, and consequently, as far as this point is concerned, a successful result.

(3) **The relations of the superficial femoral artery in the adductor (Hunter's) canal.**—The adductor canal is the somewhat triangularly shaped space bounded by the vastus medialis on the outer side, the adductors longus and magnus on the inner side, and by an aponeurosis thrown across from the adductors to the vastus in front. Below, the canal terminates at the tendinous opening in the adductor magnus; above, its limit is less well defined, as here the aponeurosis between the muscles becomes less tendinous, and gradually fades away into the perimuscular fascia. The transverse direction of the fibres of the aponeurotic covering at the lower two-thirds of the

canal is characteristic, and serves as a rallying-point in tying the artery in this part of its course. Lying superficial to the aponeurosis is the sartorius muscle. The superficial femoral artery as it lies in this canal has the following relations:—

In front, in addition to the skin, superficial and deep fascia, are the sartorius muscle and the aponeurotic fibres of the canal. The saphenous nerve crosses the artery from without inwards, lying in the wall of the canal.

Behind is the angle of meeting of the vastus medialis and the adductors.

The femoral vein lies behind the artery, but gets a little external to it at the lower part of the canal. It is here very firmly and closely attached to the artery, embracing it as it were on its posterior and external aspect. Hence it is very liable to be punctured on ligaturing the artery in this part of its course. Such an accident is best avoided by opening the sheath of the vessels well to the inner side of the front of the artery, and by keeping the point of the aneurysm needle closely applied to the vessel in passing it from without inwards between the vein and the artery. There are sometimes two veins, which then more or less surround the artery.

To its **inner side** is the adductor longus above and the adductor magnus below.

To its **outer side** is the vastus medialis, the nerve to the vastus medialis, and, at the lower part of the canal, the femoral vein.

Variations in the Femoral Artery

The more important **variations in the femoral artery** are:—(A) The femoral arising from the inferior gluteal or hypogastric, and passing out of the pelvis and down the back of the thigh with the sciatic nerve to the popliteal space; the external iliac under these circumstances ending in the profunda or external circumflex, or some other branch of the femoral. (B) A double condition of the femoral artery below the origin of the profunda; the vessel re-uniting lower down the thigh. (C) A vas aberrans given off from the inner side of the common femoral or external iliac, and joining the femoral lower down. (D) The vein may remain to the inner side of the artery its whole distance through the thigh, or it may be double, especially in the adductor canal. There is often a plexiform arrangement of the vein around the artery in this situation. (E) The variations in the origin of the profunda have been already mentioned.

BRANCHES OF THE FEMORAL ARTERY

The femoral artery gives off the following branches:—

A. From the common femoral:—(1) The superficial epigastric; (2) the superficial circumflex iliac; (3) the superficial external pudic; (4) the deep external pudic; and (5) the profunda.

B. From the superficial femoral in the femoral trigone:—(1) Muscular branches; and (2) the saphenous branch.

C. From the superficial femoral in the adductor canal:—(1) Muscular branches; and (2) the suprema genu (anastomotica magna).

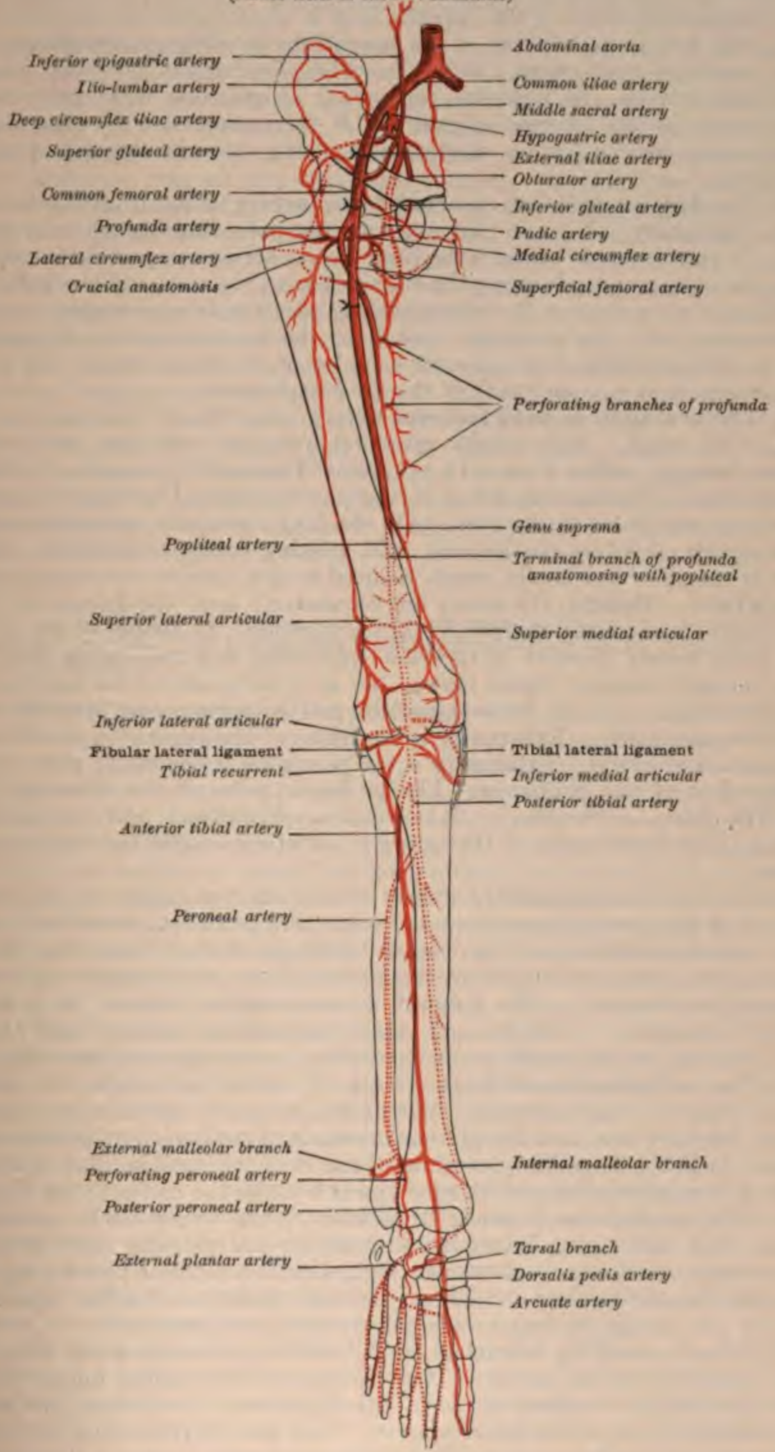
A. *Branches of the Common Femoral*

(1) The **superficial epigastric artery** comes off from the femoral about 1·2 cm. (½ in.) below Poupart's ligament. At its origin it is beneath the fascia lata, but almost at once passes through this fascia, or else through the fossa ovalis, and courses upwards and inwards in front of the external oblique muscle almost as far as the umbilicus. It ends in numerous small twigs, which anastomose with the cutaneous branches from the inferior epigastric and internal mammary. In its course it gives off small branches to the inguinal glands and to the skin and superficial fasciæ. Running with it is the superficial epigastric vein, which ends in the great saphenous just before the latter passes through the fossa ovalis (saphenous opening).

(2) The **superficial circumflex iliac artery** (fig. 460), usually smaller than the superficial epigastric, arises either in common with that vessel, or else as a separate branch from the femoral. It passes upwards and outwards over the iliacus, and, soon perforating the fascia lata a little to the outer side of the fossa ovalis, runs more or less parallel to Poupart's ligament about as far as the crest of the ilium, where it ends in branches which anastomose with the deep circumflex iliac artery. In its course it gives off branches to the iliacus and sartorius muscles, to the inguinal glands, and to the fascia and skin. Its companion vein, the superficial

ircumflex iliac, ends in the great saphenous vein just before the latter passes hrough the fossa ovalis (saphenous opening).

FIG. 461.—TO SHOW THE ANASTOMOSES OF THE ARTERIES OF THE LOWER EXTREMITY. (After Smith and Walsham.)


Inferior epigastric artery
Ilio-lumbar artery
Deep circumflex iliac artery
Superior gluteal artery
Common femoral artery
Profunda artery
Lateral circumflex artery
Crucial anastomosis
Popliteal artery
Superior lateral articular
Inferior lateral articular
Fibular lateral ligament
Tibial recurrent
Anterior tibial artery
Peroneal artery
External malleolar branch
Perforating peroneal artery
Posterior peroneal artery
External plantar artery
Abdominal aorta
Common iliac artery
Middle sacral artery
Hypogastric artery
External iliac artery
Obturator artery
Inferior gluteal artery
Pudic artery
Medial circumflex artery
Superficial femoral artery
Perforating branches of profunda
Genu suprema
Terminal branch of profunda anastomosing with popliteal
Superior medial articular
Tibial lateral ligament
Inferior medial articular
Posterior tibial artery
Internal malleolar branch
Tarsal branch
Dorsalis pedis artery
Arcuate artery

(3) The **superficial** or **superior external pudic artery** arises from the inner ide of the femoral, either a little above or else in common with the deep or inferior

external pudic. It passes either through the fascia lata, or else through the cribriform fascia covering the fossa ovalis (saphenous opening), ascends upwards and inwards over the spermatic cord in the male, or round ligament in the female, and divides into branches, one of which supplies the integument above the pubes, while another descends along the penis external to the dorsal artery, with which, and with the corresponding artery of the opposite side, it anastomoses at the corona. In the female, this branch terminates in the preputium clitoridis, anastomosing with the dorsal artery of that organ. Small branches also descend to the scrotum and labium respectively. As it crosses the cord it anastomoses with the external spermatic branch of the inferior epigastric. It is accompanied by two small veins, which usually join to form a single vein opening into the upper end of the long saphenous.

(4) The **deep** or **inferior external pudic artery** arises from the inner side of the femoral artery, either in common with the preceding branch or a little lower down. It runs inwards beneath the deep fascia, across the pectineus and adductor longus muscles, and, perforating the fascia close to the ramus of the pubis, supplies the skin of the scrotum or the corresponding part, the labium majus, in the female, anastomosing with the perinæal branch of the internal pudic. It supplies small twigs to the pectineus and adductor muscles as it crosses them. Its companion veins terminate as a single trunk in the great saphenous.

(5) The **profunda** or **deep femoral artery** (figs. 460, 461) is the chief nutrient vessel of the thigh. It is usually given off from the back and outer part of the common femoral, about 4 cm. (1½ in.) below Poupart's ligament. At first it is a little external to the femoral, but as it runs downwards and backwards it gets behind that artery and closer to the bone. On reaching the upper border of the adductor longus muscle, it leaves the femoral, and, passing beneath the muscle, pierces the adductor magnus, and finally, much reduced in size, ends in the hamstring muscles.

Relations.—Behind, the artery lies successively upon the iliacus, the pectineus, the adductor brevis, and adductor magnus muscles. **In front,** at first it is superficial, being merely covered by the skin, superficial and deep fasciæ, and branches of the femoral (anterior crural) nerve; but as it sinks behind the femoral artery, it has in front of it both the femoral and the profunda veins, and lower down the adductor longus muscle. **Externally** is the femur at the angle of union of the adductors longus and brevis. **Internally** is the pectineus at the upper part of its course.

Branches of the profunda.—The profunda gives off the following branches:—(*a*) The lateral circumflex; (*b*) the medial circumflex; and (*c*) the three perforating. The termination of the artery is sometimes called the fourth perforating branch.

(*a*) The **lateral circumflex,** a short trunk, but the largest in diameter of the branches of the artery, arises from the outer side of the profunda as it lies on the iliacus muscle, about 2 cm. (¾ in.) below the origin of that vessel from the femoral. It passes transversely outwards over the iliacus, under the sartorius and rectus, and between the branches of the femoral (anterior crural) nerve. In this course it gives off branches to the rectus and vastus intermedius (crureus), and then divides into three chief sets of branches—an ascending, transverse, and descending.

(i) The **ascending branch,** consisting of one or more separate vessels, runs upwards beneath the sartorius; then, sinking deeply beneath the tensor fasciæ latæ on the outer side, and the gluteus medius and minimus on the inner side, anastomoses with the superior gluteal and the deep circumflex iliac arteries. This branch also supplies a twig which runs upwards under the rectus to the hip-joint.

(ii) The **transverse branch,** or branches, run transversely outwards, and, winding over the vastus intermedius (crureus) and piercing the vastus lateralis, anastomose towards the back of the thigh with the superior perforating branch of the profunda, the inferior gluteal (sciatic) and medial circumflex arteries. These branches will usually be found a little below the great trochanter.

(iii) The **descending branches** run directly downwards along with the nerve to the vastus externus muscle. They lie beneath the rectus muscle and on the vastus intermedius (crureus) or vastus lateralis, some of them being just under cover of the anterior edge of the latter muscle. They are distributed to the vastus lateralis, vastus intermedius, and rectus, one branch usually running along the anterior border of the vastus lateralis as far as the knee-joint, where it anastomoses with the superior external articular branch of the popliteal (fig. 463); another, entering the vastus intermedius, anastomoses with the lower perforating branch of the profunda and with the genu suprema (anastomotica magna).

Variations of the lateral circumflex.—(A) It may come off from the femoral above the profunda. (B) It may be double, one branch coming off from the femoral, and one from the profunda, or both from the profunda, or both from the femoral above the profunda.

(*b*) The **medial circumflex artery** comes off from the back and inner part of the profunda artery on about the same level as the lateral circumflex; sometimes as a common trunk with that vessel. As it winds around the inner side of the femur to reach the region of the trochanters, it lies successively, first, between the psoas and pectineus, then between the obturator externus and adductor brevis; finally, between the adductor magnus and quadratus femoris, where it anastomoses with the lateral circumflex externally, with the inferior gluteal (sciatic) above, and with the superior perforating below, forming the so-called **crucial anastomosis.** As it passes between the obturator externus and adductor brevis, it gives off two or more branches to the adductor longus, the adductor brevis, the gracilis, and the obturator externus, and anastomoses with the obturator artery. Another small branch usually courses upwards and outwards beneath the tendon of the psoas, and enters the hip-joint beneath the transverse ligament, and, together with the articular branch of the obturator, supplies the fatty tissue in the acetabulum, and sends branches to the synovial membrane. As it lies beneath the adductor brevis, it gives off a descending branch to the adductor magnus and brevis. This branch is generally accompanied by the posterior division of the obturator nerve. Before passing between the quadratus femoris and adductor magnus, a small branch runs upwards beneath the quadratus femoris to supply the back of the hip-joint, and anastomoses with the superior and inferior gluteal arteries. Its companion veins join the profunda vein.

Variations of the medial circumflex.—(A) It may come off from the profunda artery before the lateral circumflex. (B) It may arise from the femoral artery; or (C) from the external iliac or one of its branches.

(*c*) The **perforating arteries of the profunda** are so called because they perforate, in a more or less regular manner from above downwards, certain of the adductor muscles. They form a series of loops by anastomosing with one another (fig. 461), and with the superior gluteal, medial circumflex, and inferior gluteal arteries above, and with the muscular and articular branches of the popliteal below. They are distributed chiefly to the hamstring muscles, but send twigs along the external intermuscular septum to supply the integuments at the back and outer parts of the thigh. Other branches perforate the external intermuscular septum and the short head of the biceps, and, entering the vastus intermedius (crureus) and vastus lateralis, anastomose with the descending branch of the lateral circumflex. All the perforating arteries, moreover, contribute to reinforce the artery of the sciatic nerve, a branch of the inferior gluteal (sciatic) artery. They are each accompanied by two veins which terminate in the profunda.

(i) The **first perforating artery** is given off from the profunda as that vessel sinks beneath the adductor longus. It either pierces the adductor brevis, or else runs between the pectineus and adductor brevis, and then passes through a small aponeurotic opening in the adductor magnus close to the inner lip of the linea aspera. In this course it supplies branches to the adductors, and, after perforating the adductor magnus, is distributed to the lower part of the gluteus maximus and the hamstring muscles, one branch commonly running upwards beneath the gluteus maximus to anastomose with the lateral circumflex, medial circumflex, and inferior gluteal (sciatic) arteries, forming the **crucial anastomosis** at the junction of the neck of the femur with the great trochanter (fig. 461). A second branch descends to anastomose with the ascending branch of the second perforating.

(ii) The **second perforating artery,** which is given off from the profunda as it lies behind the adductor longus, pierces the adductor brevis, and then passes through a second aponeurotic opening in the adductor magnus a little below that for the first perforating artery, and also close to the linea aspera. It supplies the hamstring muscles, sends a branch upwards to anastomose with the descending branch of the first perforating, and another downwards to anastomose in like manner with the ascending branch of the third perforating. It usually supplies the chief nutrient branch to the femur. At times, however, this comes from the third perforating.

(iii) The **third perforating artery** also arises from the profunda as it lies under the adductor longus, usually about the level of the lower border of the adductor brevis. It turns beneath this border, and then, like the first and second perforating, passes through an aponeurotic opening in the adductor magnus close to the linea aspera. It also supplies the hamstring muscles, and divides into two branches, which anastomose above with the second perforating, and below with the termination of the profunda or the fourth perforating.

(iv) The **fourth perforating** is the continuation of the profunda. It passes through an aponeurotic opening in the adductor magnus just above the opening for the femoral artery. It anastomoses, above with the third perforating, and below with the superior muscular and articular branches of the popliteal. It supplies chiefly the short head of the biceps.

B. *Branches of the Superficial Femoral in the Femoral Trigone (Scarpa's Triangle)*

The branches given off by the superficial femoral in Scarpa's triangle are usually small and insignificant. They are:—(1) **Muscular,** to the sartorius and rectus; and (2) **saphenous,** to the region of the long saphenous vein and femoral lymphatics in the neighbourhood of the vein.

C. *Branches of the Superficial Femoral in the Adductor (Hunter's) Canal*

The branches in Hunter's canal are:—(1) Muscular; and (2) the genu suprema (anastomotica magna).

(1) The **muscular branches** supply the sartorius, the rectus, the vastus medialis, the vastus intermedius (crureus), and the adductor muscles. They are usually larger than the muscular branches given off in Scarpa's triangle.

(2) The **genu suprema** or **anastomotica magna** arises from the front and inner side of the femoral just before the latter perforates the adductor magnus muscle, and almost immediately divides into two branches, (*a*) a superficial and (*b*) a deep. These branches may sometimes come off separately from the femoral.

(*a*) The **superficial branch** pierces the aponeurotic covering of the adductor canal, passes between the sartorius and gracilis muscles along with the saphenous nerve, and, perforating the deep fascia, supplies the skin of the upper and inner side of the leg and anastomoses with the inferior medial articular branch of the popliteal and the other vessels forming the plexus or rete at the inner side of the knee. In its course it gives twigs to the lower part of the sartorius and gracilis muscles.

(*b*) The **deep branch** runs downwards in front of the adductor magnus tendon, burrowing amongst the fibres of the vastus medialis as far as the internal condyle, where it passes into the plexus or rete on the inner side of the knee-joint, anastomosing with the inferior medial articular branch of the popliteal, the anterior tibial recurrent, and the superior lateral articular branch of the popliteal across the front of the femur just above the articular surface of the knee-joint. In common with the rest of the rete it sends branches into the knee-joint. It also supplies branches to the vastus medialis and vastus intermedius (crureus) muscles.

THE POPLITEAL ARTERY

The **popliteal artery** (fig. 462) runs through the popliteal space or ham. It is a continuation of the femoral, and extends from the aponeurotic opening in the adductor magnus at the junction of the middle with the lower third of the thigh to the lower border of the popliteus muscle, where it terminates by dividing into the posterior and anterior tibial arteries. This division is on a level with the lower border of the tuberosity of the tibia. As the artery passes through the opening in the adductor magnus, it is accompanied by the popliteal vein, and at times by the branch of the obturator nerve to the knee-joint. The vein throughout is behind the artery, at first lying a little external to it, but as the vessels pass through the popliteal space the vein crosses obliquely over the artery, and at the termination of the artery lies a little to its inner side. The tibial (internal popliteal) nerve is superficial to both artery and vein. As it enters the space it is well to the outer side of the vessels, but as it descends it gradually approaches them, crosses behind them, and at the lower part of the space lies to their inner side. The artery in the whole of its course is deeply placed and covered by a considerable amount of fat and cellular tissue.

Relations (fig. 462).—**In front,** the artery lies successively on the popliteal surface of the femur (from which it is separated by a little fat and sometimes one or two small glands); on the posterior ligament of the knee; on the hinder edge of the articular surface of the head of the tibia; and on the popliteus muscle. From the latter muscle it is separated by the expansion from the semi-membranosus which covers the muscle, and is attached to the oblique line on the tibia.

Behind, the artery is covered, above by the semi-membranosus; in the centre of the space by the skin, superficial and deep fascia; and below, by the inner head of the gastrocnemius. The popliteal vein is behind it in the whole of its course. The tibial (internal popliteal) nerve crosses behind it obliquely from without inwards, about the centre of the space. As the artery divides into the anterior and posterior tibial, it is crossed by the aponeurotic arch of the soleus which stretches between the tibial and fibular origins of that muscle.

To the **inner side** are the semi-membranosus above, and the inner head of the gastrocnemius and the tibial (internal popliteal) nerve below.

To the **outer side** are the biceps and the tibial (internal popliteal) nerve above, and the outer head of the gastrocnemius and the plantaris below.

Principal variations in the popliteal.—(A) It may divide higher, or more rarely lower than usual. (B) It may divide into the anterior tibial and peroneal. (C) The vein may be deeper than the artery, or separated from it by a slip of the gastrocnemius.

BRANCHES OF THE POPLITEAL ARTERY

The branches of the popliteal may be divided into—(1) The cutaneous; (2) the muscular or sural; (3) the articular; and (4) the terminal.

(1) The **cutaneous branches**—very irregular in their origin, number, and distribution—arise either from the main trunk or from one of the inferior muscular branches, pass downwards between the two heads of the gastrocnemius, and, perforating the deep fascia, supply the skin and fascia of the calf. A branch, usually of moderate size, accompanies the short or external saphenous vein, and is sometimes called the posterior saphenous artery.

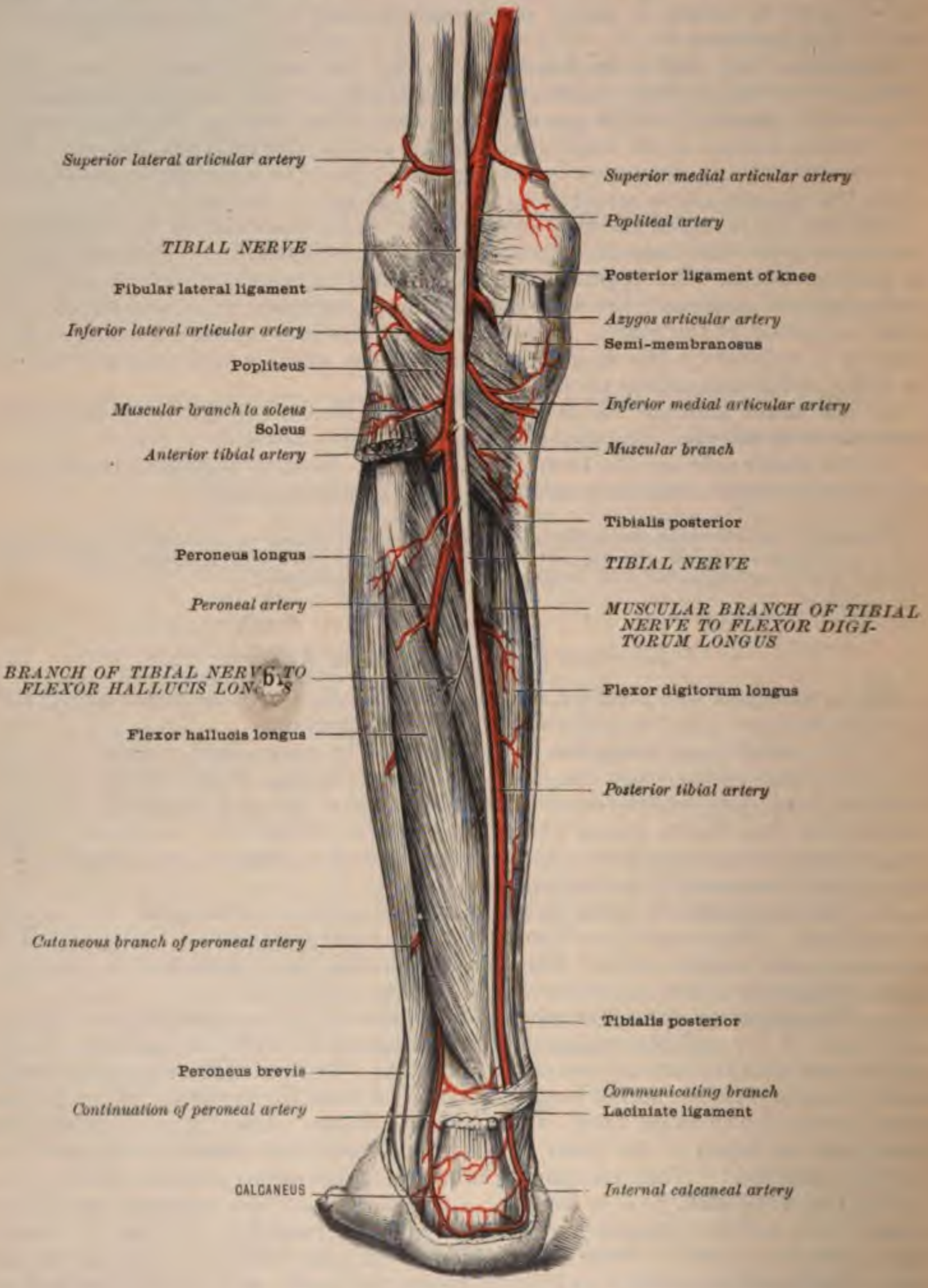
(2) The **muscular** or **sural branches** are commonly divided into the superior and inferior. They arise from the upper and lower portions of the popliteal respectively; the former supply the muscles forming the boundaries of the upper half of the popliteal space; the latter, the muscles of the calf.

(*a*) The **superior sural branches** are distributed to the hamstring muscles and lower part of the adductor magnus. They anastomose with the superior articular arteries, and with the termination of the profunda. (*b*) The **inferior sural branches,** usually two in number, and of large size, come off from the popliteal just as it passes under cover of the inner head of the gastrocnemius. They at first descend between the two heads of the latter muscle, one branch then entering the outer, and one the inner head. They also supply branches to the soleus and plantaris muscles.

(3) The **articular,** five in number, are divided into two superior (medial and lateral), two inferior (medial and lateral), and the medial or azygos, or anterior. The superior and inferior come off transversely in pairs from either side of the popliteal, the superior above, the inferior below the joint, and, winding round the bones to the front of the knee, form—by anastomosing with each other and with the genu suprema (anastomotica magna), the termination of the profunda, the descending branch of the lateral circumflex, and the anterior tibial recurrent—a superficial and deep arterial rete (fig. 463). The superficial anastomosis or rete lies between the skin and fascia round about the patella (**patellar rete**), which it sup-

plies, the larger branches entering it from above. The deep anastomosis or **articular rete** lies on the surface of the bones around the articular surfaces of the femur and tibia, supplying branches to the contiguous bones and to the joints. The azygos articular is a single short trunk coming off from the deep surface of the popliteal artery. It at once passes through the posterior ligament into the joint.

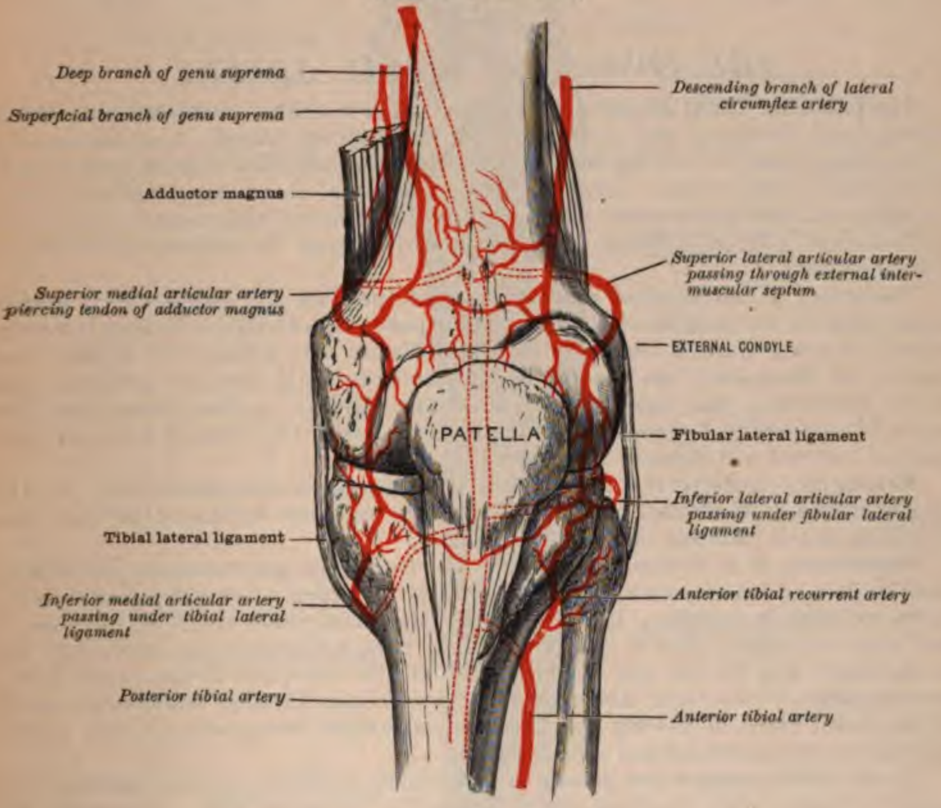
Fig. 462.—Relations of the Popliteal Artery to Bones and Muscles, left Side.


Superior lateral articular artery
TIBIAL NERVE
Fibular lateral ligament
Inferior lateral articular artery
Popliteus
Muscular branch to soleus
Soleus
Anterior tibial artery
Peroneus longus
Peroneal artery
BRANCH OF TIBIAL NERVE TO FLEXOR HALLUCIS LONGUS
Flexor hallucis longus
Cutaneous branch of peroneal artery
Peroneus brevis
Continuation of peroneal artery
CALCANEUS
Superior medial articular artery
Popliteal artery
Posterior ligament of knee
Azygos articular artery
Semi-membranosus
Inferior medial articular artery
Muscular branch
Tibialis posterior
TIBIAL NERVE
MUSCULAR BRANCH OF TIBIAL NERVE TO FLEXOR DIGITORUM LONGUS
Flexor digitorum longus
Posterior tibial artery
Tibialis posterior
Communicating branch
Laciniate ligament
Internal calcaneal artery

(*a*) The **superior lateral articular,** the larger of the two superior articular branches, runs transversely outwards above the external head of the gastrocnemius, and, passing beneath the biceps and through the external intermuscular septum and vastus lateralis, enters the substance of the vastus intermedius (crureus), and anastomoses, above with the descending branch of the lateral circumflex, below with the inferior lateral articular, and across the front of the femur with the superior medial articular, the genu suprema (anastomotica magna), and termination of the profunda, forming with them, as already described, the deep articular rete. Branches are given off to the patella, to the upper and outer part of the joint, to the bone, and to the contiguous muscles.

(*b*) The **superior medial articular** (fig. 463) runs transversely inwards just above the inner head of the gastrocnemius, beneath the semi-membranosus, and, after perforating the tendon of the adductor magnus, enters the substance of the vastus medialis, where it anastomoses with the deep branch of the genu suprema (anastomotica magna) and termination of the profunda above, with the inferior medial articular below, and with the superior lateral articular across the front of the femur. It supplies small branches to the contiguous muscles, to the femur, to the patella, and to the joint.

FIG. 463.—THE ANASTOMOSIS ABOUT THE LEFT KNEE-JOINT. (Walsham.)
(Semi-diagrammatic.)


Deep branch of genu suprema
Superficial branch of genu suprema
Adductor magnus
Superior medial articular artery piercing tendon of adductor magnus
Tibial lateral ligament
Inferior medial articular artery passing under tibial lateral ligament
Posterior tibial artery
Descending branch of lateral circumflex artery
Superior lateral articular artery passing through external inter-muscular septum
EXTERNAL CONDYLE
PATELLA
Fibular lateral ligament
Inferior lateral articular artery passing under fibular lateral ligament
Anterior tibial recurrent artery
Anterior tibial artery

(*c*) The **inferior medial articular,** the larger of the two inferior articular arteries, passes obliquely downwards and inwards across the popliteus, below the internal condyle (tuberosity) of the tibia and beneath the tibial lateral ligament to the front and inner side of the knee-joint, where it anastomoses (fig. 463), above with the superior medial articular and the superficial branch of the genu suprema (anastomotica magna), and across the front of the tibia with the inferior lateral articular. It supplies branches to the lower and inner part of the joint.

(*d*) The **inferior lateral articular** passes outwards above the head of the fibula, along the tendon of the popliteus muscle, beneath the external head of the gastrocnemius, and then under the tendon of the biceps, and between the long and short fibular lateral ligaments. Then winding to the front of the joint, it anastomoses above with the superior lateral articular, below with the anterior tibial recurrent, and across the front of the tibia with the inferior medial articular. It also supplies branches to the outer and lower part of the joint.

(*e*) The **medial** or **azygos articular** arises from the deep surface of the popliteal artery, and passes, with the articular branch of the obturator nerve, through the posterior ligament, directly into the knee-joint, where it supplies the crucial ligaments, and the patellar synovial and alar folds. It anastomoses with the intrinsic branches of the other articular arteries.

(4) The **terminal branches** of the popliteal are the posterior and anterior tibial arteries. The former appears to be a direct continuation of the vessel, and passes down the back of the leg to the inner ankle, where, on entering the sole of the foot, it divides into the medial and lateral plantar. The anterior tibial turns forwards, and, passing through the interosseous membrane, descends along the front of the leg, and ends, under the name of the dorsal artery of the foot, by anastomosing, through the first interosseous space, with the lateral plantar artery in the sole.

THE POSTERIOR TIBIAL ARTERY

The **posterior tibial artery** (fig. 464), the larger of the two branches into which the popliteal divides at the lower border of the popliteus muscle, runs downwards on the flexor aspect of the leg between the superficial and deep muscles to the back of the inner ankle, where, midway between the tip of the internal malleolus and the calcaneus, and under cover of the origin of the abductor hallucis as it arises from the laciniate (internal annular) ligament, it divides into the internal and external plantar arteries.

The artery is first situated midway between the tibia and fibula, and is deeply placed beneath the muscles of the calf. As it passes downwards it inclines inwards, and at the lower third of the leg is superficial, being only covered by the skin and fasciæ. At the ankle it lies beneath the laciniate (internal annular) ligament, and at its bifurcation also beneath the abductor hallucis. A line drawn from the centre of the popliteal space to a spot midway between the internal malleolus and point of the heel will indicate its course.

Relations.—**Anteriorly,** from above downwards, it lies successively on the tibialis posterior, the flexor digitorum longus, the posterior surface of the tibia, and the tibial lateral ligament of the ankle-joint.

Posteriorly, it is covered by the skin and fascia, the gastrocnemius and soleus, and the deep or intermuscular fascia of the leg, by which it is tightly bound down to the underlying muscles. It is crossed by the tibial nerve about an inch and a half below its origin, after it has given off its peroneal branch; the nerve first lies on the inner, and for the rest of its course on the outer side of the vessel. It is accompanied by two veins, which send numerous anastomosing branches across it. In the lower third of the leg the artery is superficial, being covered only by the skin and by the superficial and deep fasciæ.

At the **inner ankle** it lies beneath the laciniate (internal annular) ligament and abductor hallucis upon the tibial lateral ligament of the ankle-joint. Here it has the tibialis posterior and flexor digitorum longus in front of it, and the tibial nerve and the flexor hallucis longus behind and to its outer side.

At times the tibial nerve divides higher than usual, when one branch lies on the inner side of the artery and the other branch on the outer side.

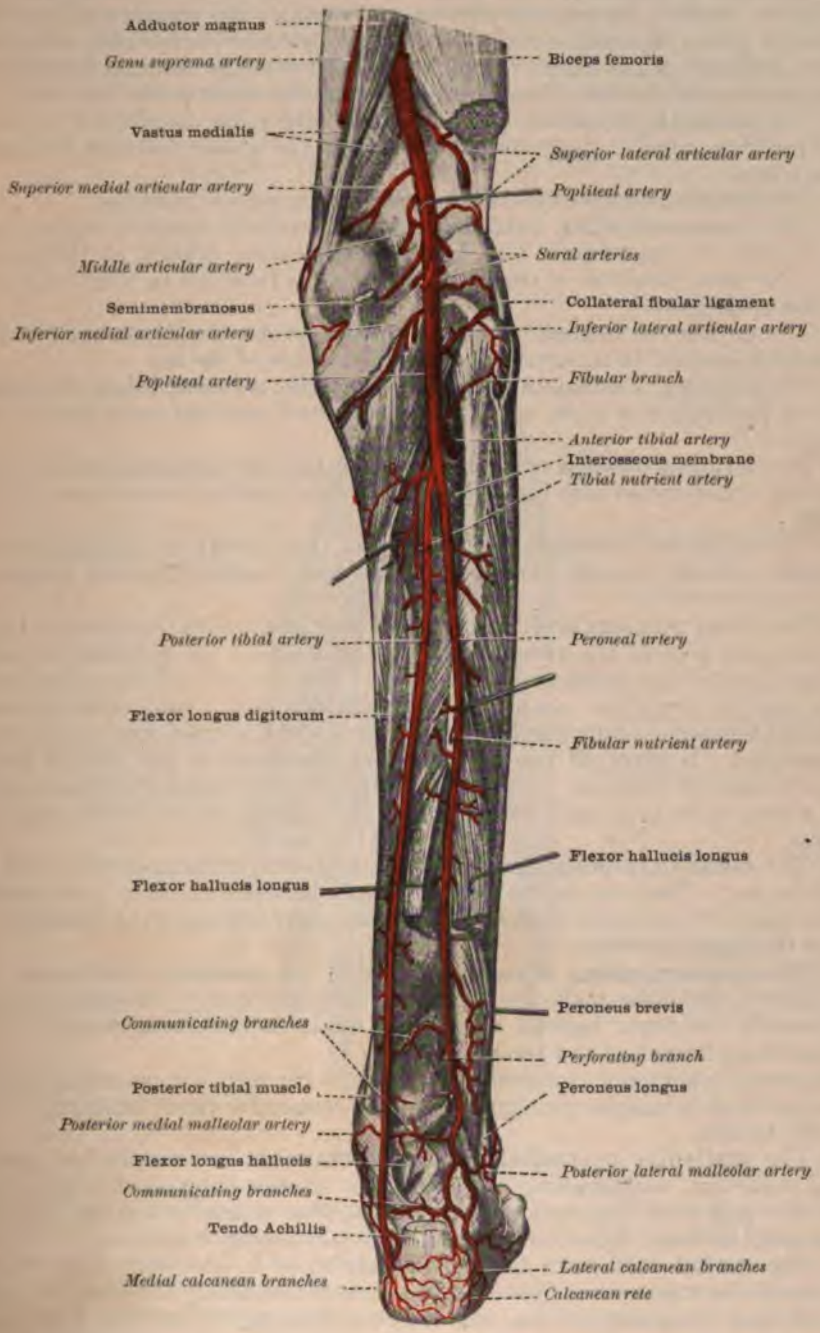
The **branches of the posterior tibial artery** are:—(1) The peroneal; (2) the muscular; (3) the tibial nutrient; (4) the cutaneous; (5) the communicating; (6) the malleolar; (7) the calcanean, or internal calcanean; and (8) the terminal, i.e. the external and internal plantar arteries.

(1) The **peroneal artery** (figs. 462, 464) arises from the posterior tibial about 2·5 cm. (1 in.) below the lower border of the popliteus muscle. At first forming a gentle curve with the convexity outwards, it approaches the fibula, and continues its course downwards close to that bone as far as the lower end of the interosseous membrane, where it gives off a large branch, the perforating (anterior peroneal), and then, passing over the back of the inferior tibio-fibular joint, terminates by breaking up into a network, which is distributed over the back of the external mal-

leolus and outer surface of the calcaneus (fig. 468). It is accompanied by two venæ comites.

Relations.—At its upper part it is deeply placed between the tibialis posterior and soleus muscles, and beneath the deep or intermuscular fascia. For the rest of its course to the ankle it lies beneath, or sometimes in the substance of, the flexor hallucis longus in the angle between the fibula and interosseous membrane. After giving off the perforating branch, it is only covered, as it lies behind the tibio-fibular

Fig. 464.—The Popliteal, the Posterior Tibial, and the Peroneal Arteries. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Adductor magnus
Genu suprema artery
Biceps femoris
Vastus medialis
Superior lateral articular artery
Superior medial articular artery
Popliteal artery
Sural arteries
Middle articular artery
Semimembranosus
Collateral fibular ligament
Inferior medial articular artery
Inferior lateral articular artery
Popliteal artery
Fibular branch
Anterior tibial artery
Interosseous membrane
Tibial nutrient artery
Posterior tibial artery
Peroneal artery
Flexor longus digitorum
Fibular nutrient artery
Flexor hallucis longus
Flexor hallucis longus
Peroneus brevis
Communicating branches
Perforating branch
Posterior tibial muscle
Peroneus longus
Posterior medial malleolar artery
Flexor longus hallucis
Posterior lateral malleolar artery
Communicating branches
Tendo Achillis
Lateral calcanean branches
Medial calcanean branches
Calcanean rete

articulation, by the integuments and deep fascia, and in this part of its course is sometimes called the **posterior peroneal.**

The **branches of the peroneal artery** are:—(*a*) The perforating (anterior peroneal); (*b*) the muscular; (*c*) the fibular nutrient; (*d*) the communicating; (*e*) the cutaneous; (*f*) the external calcanean; and (*g*) the terminal.

(*a*) The **perforating** or **anterior peroneal artery** arises from the front of the peroneal artery at the lower part of the interosseous space, and, passing through the interosseous membrane, runs downwards over the front of the inferior tibio-fibular joint, beneath the peroneus tertius, and supplies this muscle and the inferior tibio-fibular joint. It anastomoses with the tarsal, arcuate (metatarsal) and external malleolar branches of the anterior tibial artery, and with the external plantar artery on the outer side of the foot, forming a plexus over the outer ankle (fig. 467).

(*b*) The **muscular branches** of the peroneal artery are distributed to the contiguous muscles, namely: the flexor hallucis longus, the tibialis posterior, the peronei, and the soleus.

(*c*) The **fibular nutritive** enters the nutrient foramen of the fibula.

(*d*) The **communicating branches** pass transversely inwards in front of the tendo Achillis to anastomose with the communicating branch of the posterior tibial. The usual situation of this communication is from 2·5 to 5 cm. (1 to 2 in.) above the ankle-joint.

(*e*) The **cutaneous branches** run outwards between the flexor hallucis longus and soleus to supply the integuments on the outer side of the leg.

(*f*) The **external calcanean** comes off from the peroneal below the point at which the perforating is given off, and is distributed over the outer surface of the calcaneus.

(*g*) The **terminal branch** or **posterior peroneal,** the continuation of the peroneal artery, anastomoses with the other arteries distributed to the external malleolus and heel.

(2) The **muscular branches** of the posterior tibial artery are distributed to the contiguous muscles, namely: the tibialis posterior, flexor digitorum longus, and soleus.

(3) The **tibial nutrient artery,** a vessel of large size, leaves the posterior tibial at its upper part, pierces the tibialis posterior, and enters the nutrient foramen in the upper third of the posterior surface of the tibia. In the interior of the bone it divides into two branches: an ascending or smaller, which runs upwards towards the head of the bone; and a descending or larger, which courses downwards towards the lower end. It gives off two or three muscular twigs to the tibialis posterior before it enters the foramen. The nutrient artery of the tibia is the largest nutrient artery of bone in the body, and is accompanied by a nerve given off by the nerve to the popliteus.

(4) The **cutaneous branches** pass inwards to the integuments on the inner side of the leg. They run in the cellular planes between the deep and superficial muscles, and serve as useful guides to the vessel when ligaturing the posterior tibial through the lateral incision.

(5) The **communicating branch** arises from the posterior tibial about 5 cm. (2 in.) above the inner malleolus, and, passing transversely outwards across the tibia beneath the flexor hallucis longus and tendo Achillis, anastomoses with the communicating branch of the peroneal.

Frequently an inferior communicating branch between the posterior tibial and peroneal arteries is likewise present in the loose connective tissue beneath or behind the tendo Achillis.

(6) The **malleolar** or **medial malleolar branches** are distributed over the internal malleolus, anastomosing with the other arteries entering into the retiform plexus of vessels over that portion of bone. In their course to the malleolus, they run beneath the flexor digitorum longus and tibialis posterior muscles.

(7) The **medial calcanean branch** is distributed to the soft parts over the inner side of the calcaneus. This branch—or, as is frequently the case, branches—comes off from the posterior tibial just before its bifurcation, and anastomoses with the internal malleolar and peroneal arteries.

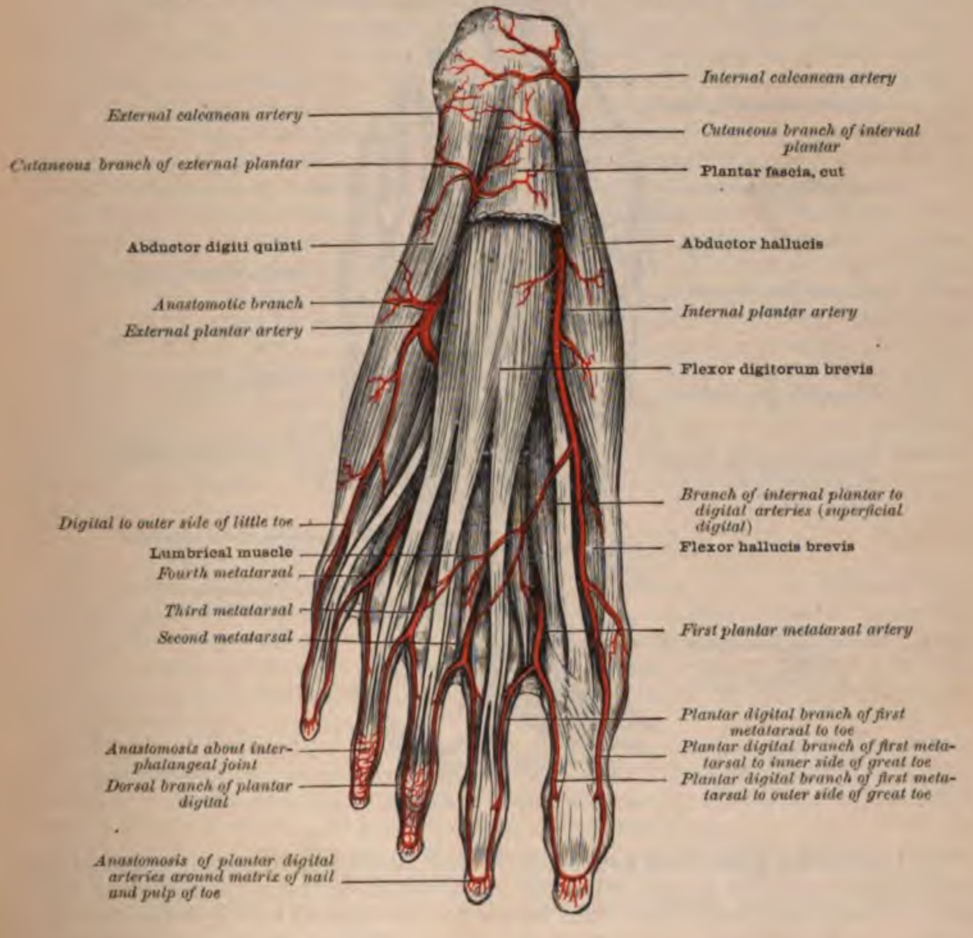
(8) The **terminal branches** are the lateral and medial plantar arteries.

THE LATERAL PLANTAR ARTERY

The **lateral plantar artery**—the larger of the two branches into which the posterior tibial divides beneath the laciniate (internal annular) ligament—passes at first obliquely forwards and outwards across the sole of the foot to the base of the fifth metatarsal bone, where it makes a bend forwards and inwards, and, sinking deeply into the foot, terminates at the proximal end of the first interosseous space by anastomosing with the deep plantar (communicating) branch of the dorsal artery of the foot. In its course to the fifth metatarsal bone the artery runs in a more or less straight line obliquely across the foot; whilst its deep portion, extending from the fifth metatarsal bone to the proximal end of the first interosseous space, forms a slight curve with the convexity forwards, and is known as the **plantar arch.** The plantar arch is comparable to the deep volar arch formed by the deep branch of the ulnar anastomosing with the radial through the first interosseous space. This homology is at times more complete in that the deep plantar (communicating) branch of the dorsalis pedis, the homologue of the radial in the upper limb, takes the chief share in forming the arch. The lateral plantar artery is accompanied by two veins. The course of the artery is indicated by a line drawn across the sole of the foot from a point midway between the tip of the internal malleolus and the greater tubercle of the calcaneus to the base of the fifth metatarsal bone, and thence forwards and inwards to the posterior part of the ball of the great toe.

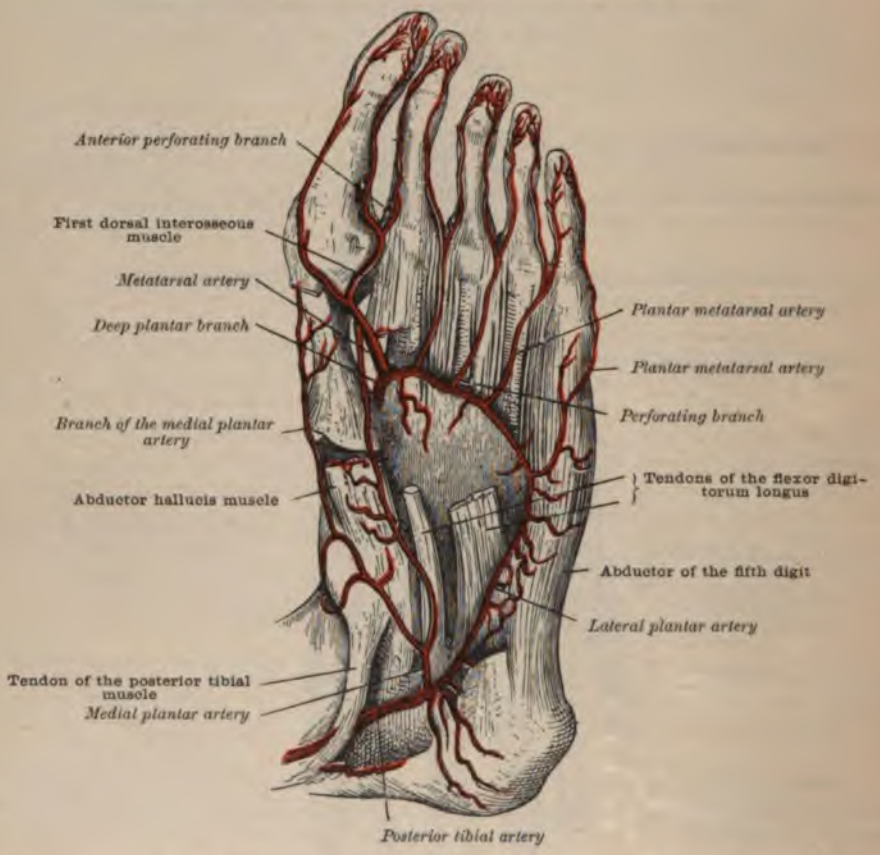
Fig. 465.—The Plantar Arteries, Left Foot.

(From a dissection in the Museum of St. Bartholomew's Hospital.)


Internal calcanean artery
External calcanean artery
Cutaneous branch of internal plantar
Cutaneous branch of external plantar
Plantar fascia, cut
Abductor digiti quinti
Abductor hallucis
Anastomotic branch
External plantar artery
Internal plantar artery
Flexor digitorum brevis
Branch of internal plantar to digital arteries (superficial digital)
Digital to outer side of little toe
Lumbrical muscle
Flexor hallucis brevis
Fourth metatarsal
Third metatarsal
Second metatarsal
First plantar metatarsal artery
Plantar digital branch of first metatarsal to toe
Anastomosis about interphalangeal joint
Plantar digital branch of first metatarsal to inner side of great toe
Dorsal branch of plantar digital
Plantar digital branch of first metatarsal to outer side of great toe
Anastomosis of plantar digital arteries around matrix of nail and pulp of toe

Relations.—In the **first part of its course** from the inner ankle to the base of the fifth metatarsal bone, the artery is covered successively by the abductor hallucis and the flexor digitorum brevis, by which it is separated from the plantar fascia, and may be slightly overlapped in muscular subjects by the abductor quinti digiti. As it approaches the base of the fifth metatarsal bone it lies, as it turns forwards and inwards before sinking into the foot, in the interspace between the flexor digitorum brevis and the abductor quinti digiti, and is here only covered by the skin and superficial fascia and the plantar fascia. It lies upon the calcaneus, the quadratus plantæ (flexor accessorius), and the flexor digiti quinti brevis. It is accompanied by the lateral plantar nerve, the smaller of the two divisions into which the tibial nerve divides. In this part of its course it gives off small branches to the contiguous muscles and to the heel.

Fig. 466.—Plantar Arteries (Deep). (After Henle.)


Anterior perforating branch
First dorsal interosseous muscle
Metatarsal artery
Deep plantar branch
Branch of the medial plantar artery
Abductor hallucis muscle
Tendon of the posterior tibial muscle
Medial plantar artery
Plantar metatarsal artery
Plantar metatarsal artery
Perforating branch
Tendons of the flexor digitorum longus
Abductor of the fifth digit
Lateral plantar artery
Posterior tibial artery

In the **second part of its course** the artery, which is here known as the plant arch, sinks into the sole, and is covered, in addition to the skin, superficial fasc plantar fascia, and flexor digitorum brevis by the tendons of the flexor digitor longus, the lumbricales, branches of the internal plantar nerve, and the adduct hallucis. It lies upon the proximal ends of the second, third, and fourth metatar bones and the corresponding interosseous muscles.

The **branches of the lateral plantar artery** are:—(1) Muscular; (2) c caneal; (3) cutaneous; (4) anastomotic; (5) articular; (6) posterior perforati and (7) plantar metatarsal (digital).

(1) The **muscular branches** of the lateral plantar are distributed to the co tiguous muscles; in the first part of its course to the flexor digitorum brevis, and t quadratus plantæ (flexor accessorius); as it makes its bend into the sole, to the musc of the little toe; and, as it forms the plantar arch, to the interossei, flexor hallu *brevis*, and adductor hallucis.

(2) The **calcanean** are two or three small branches which are distributed over the inner surface of the calcaneus, and anastomose with the internal calcanean branch of the posterior tibial artery.

(3) The **cutaneous** pass between the abductor digiti quinti and flexor digitorum brevis, and through the interval between the middle and outer portions of the plantar fascia, to the skin.

(4) The **anastomotic** turn over the outer border of the foot, and anastomose with the tarsal and metatarsal branches of the dorsalis pedis (fig. 467).

(5) The **articular** come off from the concavity of the arch, and, running backwards and upwards, are distributed to the articulations of the tarsus. They are homologous to the recurrent branches of the deep palmar arch in the hand, and, like the latter, are usually three in number.

(6) The **posterior perforating,** also three in number, ascend through the proximal end of the second, third, and fourth spaces, between the two heads of the correspondingly named dorsal interosseous muscles, and communicate with the proximal ends of the first, second, and third dorsal metatarsal (interosseous) arteries (fig. 466).

(7) The **plantar metatarsal (digital) arteries** are usually four in number, and pass forward in the four intermetatarsal spaces, which are numbered from within outwards. They rest upon the interosseous muscles of their spaces, and are at first under cover of the lumbricals, but as they approach the clefts of the toes each divides into two branches, the **plantar (collateral) digital arteries,** which supply the contiguous sides of the toes. The plantar digital branch for the inner side of the great toe is usually given off by the first plantar metatarsal; that for the outer side of the little toe is usually a separate branch from the outer end of the plantar arch.

The digital arteries, immediately before they bifurcate, send upwards on to the dorsum of the foot a communicating branch (the anterior perforating artery) to the corresponding dorsal metatarsal arteries. On the side of the toes they furnish numerous small branches to the integument and to the flexor tendons and their sheaths. They anastomose by many small twigs with the dorsal metatarsal arteries, which also run along the sides of the toes, but more towards the dorsal aspect. Immediately above each phalangeal joint the plantar digital vessels communicate by cross branches, forming a rete for the supply of the articular end of the phalanges and the contiguous joints. At the distal end of the toes they also freely anastomose with each other, forming a rete beneath the pulp and around the matrix of the nail. The digital arteries are each accompanied by two small veins.

THE MEDIAL PLANTAR ARTERY

The **medial plantar artery** (fig. 466)—the smaller of the two divisions into which the posterior tibial divides at the inner ankle—passes forwards along the inner side of the sole of the foot usually to the first interosseous space, where it ends by anastomosing either with the first plantar metatarsal artery derived from the plantar arch, or with the branch given off by the first plantar metatarsal to the inner side of the great toe.

Relations.—The artery is at first under cover of the abductor hallucis, but afterwards lies in the interval between that muscle and the flexor digitorum brevis. It is covered by the skin and superficial fascia, but not by the plantar fascia, since it lies between the middle and inner portions of that structure.

The branches of the medial plantar are small and irregular in their origin, course, and distribution. The following are described:—

(1) The **muscular branches** supply the abductor hallucis, and flexor digitorum brevis.

(2) The **cutaneous branches** supply the skin over the course of the vessel.

(3) The **articular** sink deeply into the sole, and supply the articulations on the inner side of the foot, and anastomose with the branches of the lateral plantar artery.

(4) The **anastomotic** run beneath the abductor hallucis and round the inner side of the foot, to anastomose with the internal tarsal branch of the dorsalis pedis.

(5) The **superficial digital** are very small twigs which accompany the digital branches of the medial plantar nerves, and anastomose with the plantar metatarsal arteries in the first, second, and third spaces. At times a twig from one of these branches joins the lateral plantar artery to form a superficial plantar arch.

THE ANTERIOR TIBIAL ARTERY

The **anterior tibial artery** (fig. 467)—the smaller of the two branches into which the popliteal artery divides at the lower border of the popliteus muscle—at first courses forwards between the two heads of origin of the tibialis posterior, and, after passing between the tibia and fibula above the upper part of the interosseous membrane, runs downwards on the front and outer aspect of the leg, between the anterior muscles, as far as the front of the ankle-joint. Below this spot it is known as the dorsalis pedis. The **course of the vessel** is indicated by a line drawn from the front of the head of the fibula to a point midway between the two malleoli.

The artery is accompanied by two veins which communicate with each other at frequent intervals across it. It is also accompanied in the lower three-fourths of its course by the deep peroneal nerve. The nerve, which winds round the head of the fibula, and pierces the extensor digitorum longus, first comes into contact with the outer side of the artery somewhat about the upper third of the leg; then, in the middle third of the leg, it gets a little in front of the artery, and in the lower third again lies to its outer side.

Relations.—The artery at first lies in the triangle formed by the two heads of the tibialis posterior and the popliteus muscle; and, as it passes through the hole in the interosseous membrane, it has the tibia on one side and the fibula on the other. It is separated from the deep peroneal (anterior tibial) nerve at its commencement by the neck of the fibula and the extensor digitorum longus. This arrangement is homologous with that met with in the forearm in the case of the posterior interosseous artery and deep radial (posterior interosseous) nerve.

Posteriorly in its course down the leg it lies in its upper two-thirds upon the interosseous membrane, to which it is closely bound by fibrous bands; and in its lower third upon the front of the tibia and the ankle-joint.

To its **inner side** along its upper two-thirds is the tibialis anterior muscle; but at the lower third it is crossed by the tendon of the extensor hallucis proprius, and then for the rest of its course has this tendon overlapping it or to its inner side.

On its **outer side** it is in contact in its upper third with the extensor digitorum longus muscle; in its middle third with the extensor hallucis proprius; but, as this muscle crosses to the inner side of the artery, the vessel usually for a very short part of its course comes again into contact with the extensor digitorum longus. At the upper and lower thirds of its course on the front of the leg the artery has the deep peroneal (anterior tibial) nerve to its outer side.

In front the artery is covered by the skin, superficial and deep fascia. In its upper two-thirds it is deeply placed in the cellular interval between the tibialis anterior on the inner side, and the extensor digitorum longus and extensor hallucis proprius on its outer side; and in its lower third it is crossed from without inwards by the tendon of the extensor hallucis proprius, and lies beneath the crucial (anterior annular) ligament of the ankle-joint. The deep peroneal nerve is usually in front of the artery in the middle third of the leg.

The **branches of the anterior tibial artery** are:—(1) The posterior tibial recurrent; (2) the superior fibular; (3) the anterior tibial recurrent; (4) the muscular; (5) the medial malleolar; and (6) the lateral malleolar.

(1) The **posterior tibial recurrent** is occasionally absent. It ascends between the popliteus muscle and the posterior ligament of the knee-joint, supplying these structures and the superior tibio-fibular joint. It anastomoses with the inferior lateral articular branch of the popliteal, and to a less extent with the inferior medial articular branch.

(2) The **superior fibular** is a branch of small size which arises from the main trunk just before it passes through the interosseous space. It winds around the neck of the fibula, pierces the attachment of the soleus, and is distributed to that muscle and to the skin.

(3) The **anterior tibial recurrent** is given off from the anterior tibial artery immediately after that vessel has passed through the interosseous membrane. It winds tortuously through the substance of the tibialis anterior muscle, over the outer condyle (tuberosity) of the tibia close to the bone; and, perforating the deep fascia, ramifies on the lower and outer part of the capsule of the knee-joint. It anas-

tomoses with the inferior and superior lateral articular branches of the popliteal, with the descending branch of the lateral circumflex, and somewhat less freely with the medial articular branches of the popliteal and with the genu suprema (anastomotica magna). It gives off small branches to the tibialis anterior, the extensor digitorum longus, the knee-joint, and the contiguous fascia and skin. It forms one of the collateral channels by which the blood is carried to the limb below in obstruction of the popliteal artery (fig. 467).

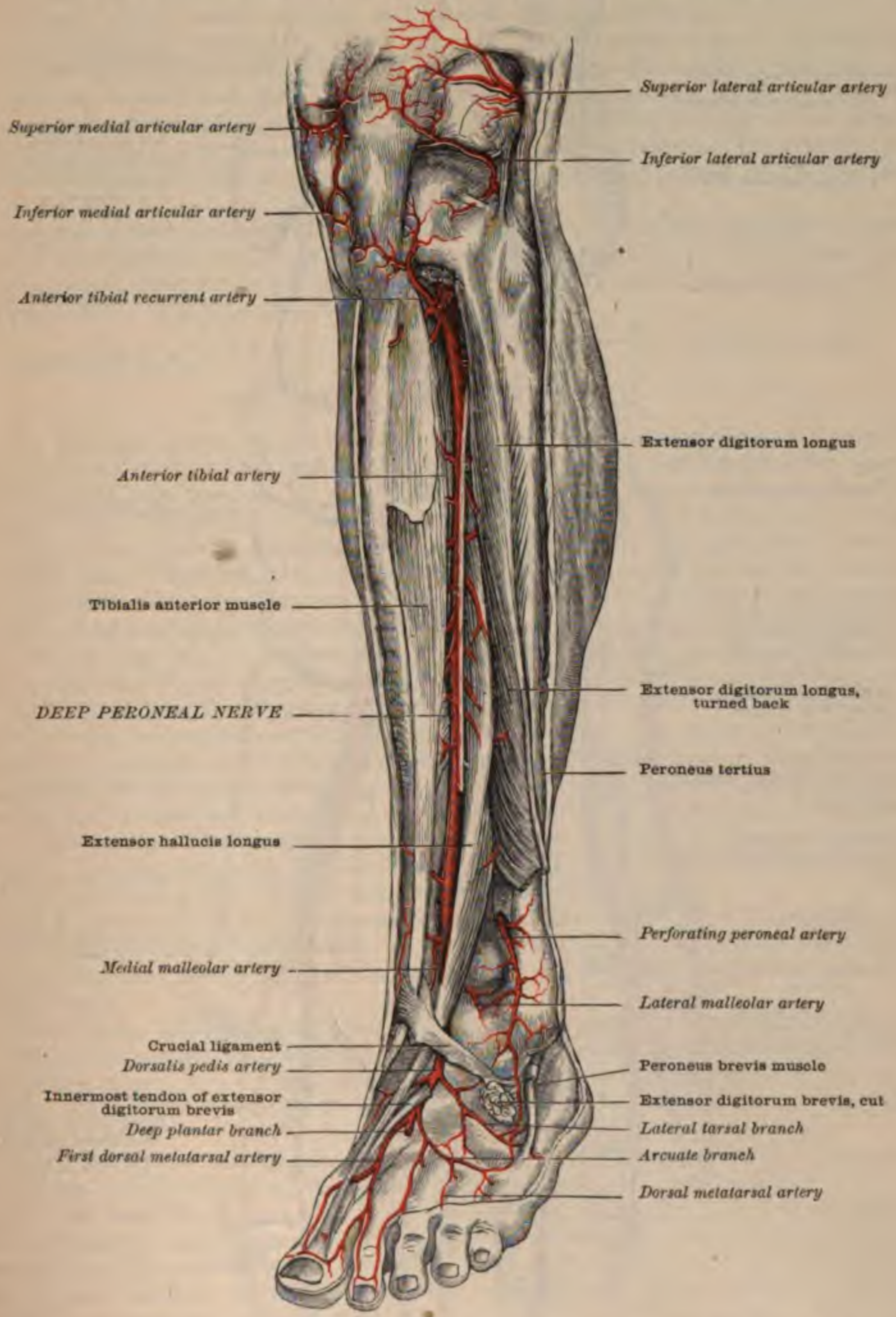


FIG. 467.—THE ANTERIOR TIBIAL ARTERY, DORSAL ARTERY OF THE FOOT, AND PERFORATING (ANTERIOR) PERONEAL ARTERY, AND THEIR BRANCHES, LEFT SIDE.

Superior lateral articular artery
Superior medial articular artery
Inferior lateral articular artery
Inferior medial articular artery
Anterior tibial recurrent artery
Extensor digitorum longus
Anterior tibial artery
Tibialis anterior muscle
Extensor digitorum longus, turned back
DEEP PERONEAL NERVE
Peroneus tertius
Extensor hallucis longus
Perforating peroneal artery
Medial malleolar artery
Lateral malleolar artery
Crucial ligament
Dorsalis pedis artery
Peroneus brevis muscle
Innermost tendon of extensor digitorum brevis
Extensor digitorum brevis, cut
Deep plantar branch
Lateral tarsal branch
First dorsal metatarsal artery
Arcuate branch
Dorsal metatarsal artery

(4) The **muscular branches,** some ten or twelve in number, arise irregularly

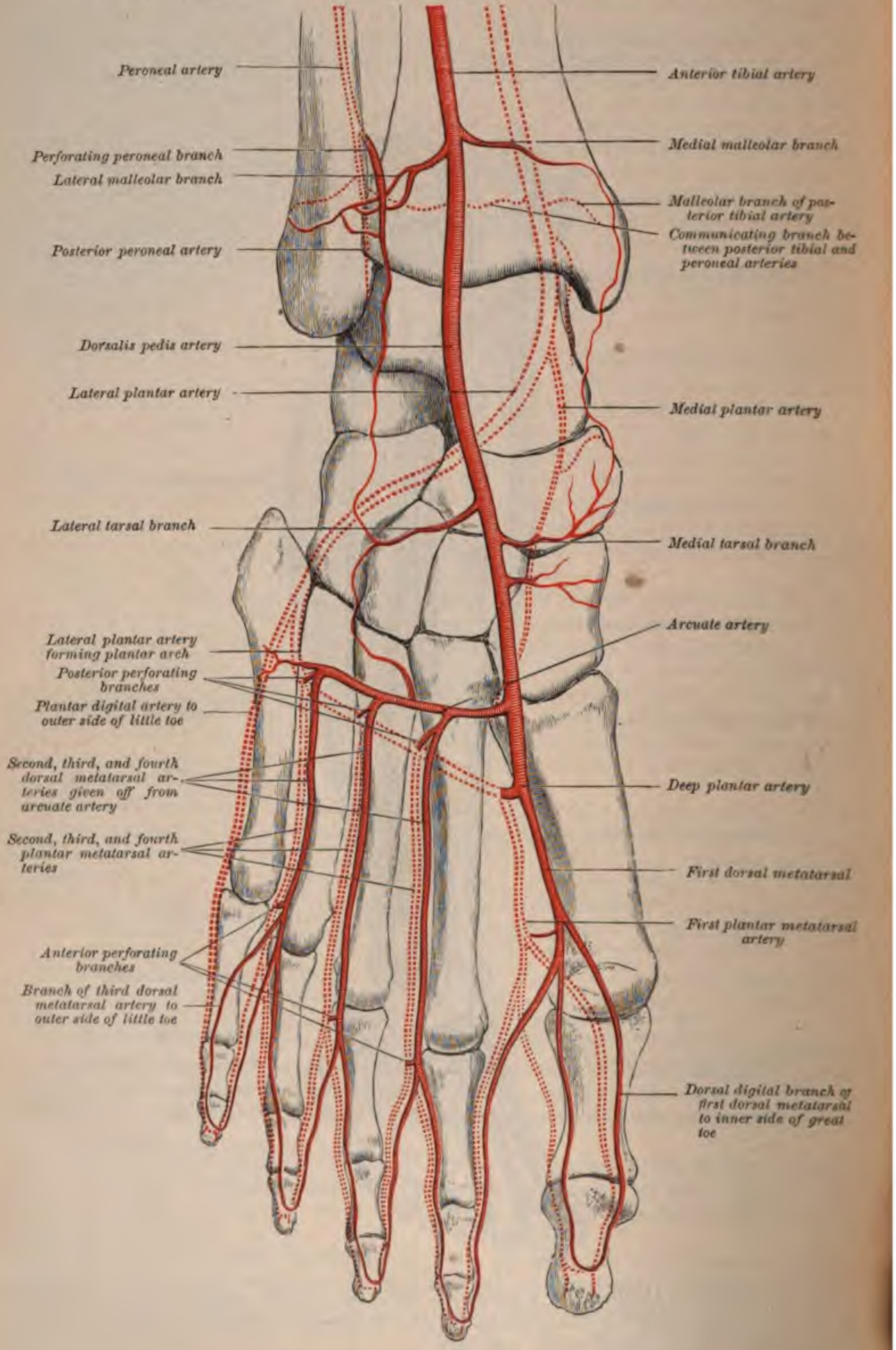


FIG. 468.—SCHEME OF THE DISTRIBUTION AND ANASTOMOSES OF THE ARTERIES OF THE RIGHT FOOT. (Walsham.)

(The plantar arteries are shown in dotted outline; the dorsal in solid red.)

Peroneal artery
Anterior tibial artery
Perforating peroneal branch
Medial malleolar branch
Lateral malleolar branch
Malleolar branch of posterior tibial artery
Communicating branch between posterior tibial and peroneal arteries
Posterior peroneal artery
Dorsalis pedis artery
Lateral plantar artery
Medial plantar artery
Lateral tarsal branch
Medial tarsal branch
Arcuate artery
Lateral plantar artery forming plantar arch
Posterior perforating branches
Plantar digital artery to outer side of little toe
Second, third, and fourth dorsal metatarsal arteries given off from arcuate artery
Deep plantar artery
Second, third, and fourth plantar metatarsal arteries
First dorsal metatarsal
First plantar metatarsal artery
Anterior perforating branches
Branch of third dorsal metatarsal artery to outer side of little toe
Dorsal digital branch of first dorsal metatarsal to inner side of great toe

from either side of the artery as it courses down the limb, and supply the contiguous muscles.

(5) The **medial malleolar,** the smaller of the two malleolar branches, arises from the lower part of the anterior tibial artery a little higher than the lateral, usually about the spot where the tendon of the extensor hallucis longus crosses the anterior tibial artery. It winds inwards over the internal malleolus, passing beneath the tibialis anterior, and forms a medial malleolar plexus or rete about the inner ankle over the lower end of the tibia by anastomosing with branches from the posterior tibial, medial plantar, and internal calcanean arteries.

(6) The **lateral malleolar,** larger than the medial, arises from the outer side of the anterior tibial artery, usually on a lower level than the medial malleolar. It winds in an outward and downward direction round the external malleolus, passing beneath the extensor digitorum longus and peroneus tertius, and forms the lateral malleolar plexus or rete by anastomosing with the anterior peroneal, the termination of the peroneal, the lateral plantar, and the lateral tarsal branch of the dorsalis pedis (fig. 467).

The anastomosis between the lateral malleolar and perforating peroneal is sometimes of considerable size, supplying the blood to the dorsal artery of the foot; the anterior tibial, then much reduced in size, usually ends at the spot where the lateral malleolar is usually given off.

THE DORSALIS PEDIS ARTERY

The **dorsalis pedis artery** is a continuation of the anterior tibial. It extends from the front of the ankle-joint to the proximal end of the first interosseous space, where it dips into the sole to join the lateral plantar artery and complete the plantar arch. The course of the artery is indicated by a line drawn from a point midway between the two malleoli to the proximal end of the first metatarsal space.

Relations.—Behind, the artery from above downwards lies successively on the talus (astragalus), navicular, second cuneiform, and the base of the second metatarsal bones, and the ligaments uniting these bones. As it sinks into the sole, under the name of the deep plantar (communicating) artery, it lies between the two heads of origin of the first dorsal interosseous muscle. At times it takes a course a little more outwards, then lying either partly on the second cuneiform bone, or on the dorsal ligaments uniting the second cuneiform to the first cuneiform. It is more or less bound down to the bones by aponeurotic fibres derived from the deep fascia.

In front, the artery is covered by the crucial (anterior annular) ligament, sometimes by the extensor hallucis longus, by the skin, the superficial and deep fascia, and, just before it sinks into the sole, by the innermost tendon of the extensor digitorum brevis. The angle formed by this tendon with the extensor hallucis longus is the best guide to finding the artery in the process of ligature (fig. 467).

To its **outer side** is the innermost tendon of the extensor digitorum longus, and lower down the innermost tendon of the extensor digitorum brevis. The deep peroneal (anterior tibial) nerve is also to its outer side, as is also the outermost of its venæ comites.

To its **inner side** is the extensor hallucis longus, except at times for about half an inch below, where the innermost tendon of the extensor digitorum brevis, having crossed the artery, may lie between it and this tendon. The innermost of the venæ comites is also to the inner side. Branches between the venæ comites at intervals cross the vessel.

The **branches of the dorsalis pedis artery** are:—(1) The tarsal; (2) the arcuate; (3) the first dorsal metatarsal (dorsalis hallucis), and (4) the deep plantar.

(1) The **tarsal branches** may be divided into (*a*) the medial, and (*b*) the lateral. (*a*) The **lateral tarsal** runs outwards over the navicular and cuboid bones, beneath the extensor digitorum brevis. It supplies branches to that muscle, and to the bones and the articulations between them, and anastomoses above with the lateral malleolar and perforating (anterior) peroneal, below with the arcuate (metatarsal) and externally over the outer border of the foot with the anastomotic branches of the lateral plantar artery. (*b*) The **medial tarsal** consists of a few small branches which run over the inner side of the foot, supplying the skin and articulations, and anastomose with the medial malleolar.

(2) The **arcuate (metatarsal) artery** (figs. 467 and 468) runs outwards across the foot, in a slight curve with the convexity forwards, over the bases of the metatarsal bones, and beneath the extensor tendons and the extensor digitorum brevis. At the outer border of the foot it anastomoses, above with the lateral tarsal, and externally with the anastomotic branches of the lateral plantar. From the convexity of the arch it gives off three **dorsal metatarsal** (interosseous) **arteries,** which run forwards on the dorsal interosseous muscles in the centre of the second, third, and fourth interosseous spaces to the cleft of the toes, where they bifurcate for the supply of the contiguous sides of the second and third toes, the third and fourth toes, and the fourth and fifth toes. The outermost of the interosseous branches gives off a small vessel for the supply of the outer side of the little toe. At the proximal end of the second, third, and fourth interosseous spaces each artery receives a branch of communication from the lateral plantar artery (posterior perforating), and immediately before they bifurcate a second communicating artery through the distal end of the interosseous space from the corresponding digital (anterior perforating artery).

The **dorsal digital vessels,** into which the dorsal interosseous arteries divide at the cleft of the toes, run along the side of each toe towards the dorsal aspect, anastomosing with each other across the dorsum of the toes and by frequent branches with the digital branches of the plantar metatarsal arteries, which also run along the sides of the toes, but nearer the plantar surface. At the end of the toes they anastomose with each other around the quick of the nail.

(3) The **first dorsal interosseous** or **dorsalis hallucis artery** is the apparent continuation of the dorsalis pedis. Like the other dorsal metatarsal arteries, it passes forwards, in the centre of the first interosseous space, on the first dorsal interosseous muscle. At the cleft of the toes it divides into two **dorsal digital branches**—the one for the supply of the outer side of the great toe, the other for the inner side of the second toe. Before its bifurcation the artery gives off a small branch, which runs inwards, under the extensor hallucis longus, for the supply of the inner side of the great toe; but this branch is sometimes absent. At the front of the space, immediately before its bifurcation, the first dorsal metatarsal communicates with the first plantar metatarsal (digital) artery, through an anterior perforating artery.

(4) The **deep plantar (communicating)** comes off from the dorsalis pedis with the first dorsal metatarsal (into which arteries indeed the dorsalis pedis may be said to divide). At the back of the first interosseous space it dips into the sole between the two heads of the first dorsal interosseous muscle, and communicates with the termination of the lateral plantar artery, completing the plantar arch, in a manner similar to that in which the radial artery, passing through the first dorsal interosseous muscle in the hand, completes by anastomosing with the ulnar the deep palmar arch.

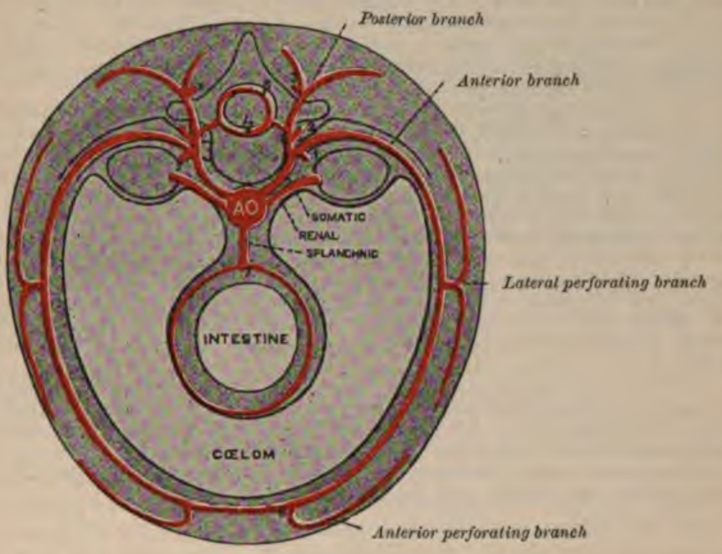
The Morphology of the Arterial System

From the embryonic aorta are given off two sets of segmental branches, lateral or **somatic,** to the body wall, and ventral or **splanchnic,** to the viscera. In the region of the arm and leg the somatic branches become large and modified from the simple type form. In considering these somatic and splanchnic branches four general facts of growth should be kept in mind:—First, that the arterial system grows from centre to periphery; that the growth is by means of the sprouting of the endothelial coat of the vessels; and that the vessels gradually invade nearly all parts of the body. There are at first non-vascular areas, which later become vascular. Second, that in the process of development there is a great shifting of parts, for example, the descent of the diaphragm and heart from the neck, or the shifting of the rectus abdominis muscle from the side to the front. All such changes involve a shifting of the blood-vessels. Third, that in the process of development there is an abundant destruction of blood-vessels; and fourth, that the formation of and variation in anastomotic channels play a large part in the development of the vascular system.

The **somatic arteries.**—The somatic arteries are of two types (1) the paired segmental branches, which supply the body wall, and (2) a few mediastinal branches that supply the septa of the body cavity, such as the diaphragm. The segmental somatic branches are given off in the cervical, thoracic, lumbar, and sacral regions. A typical somatic artery is shown by the upper intercostal arteries. Like the intercostal nerves, they divide into posterior and anterior branches. The posterior branch passes backwards and supplies the spinal canal, the dorsal muscles, and skin, while the anterior branch passes around to the front of the body with the intercostal nerve and gives off lateral and anterior perforating branches. There are anastomoses between these branches in a given segment; as, for example, the connections across the median line shown in fig. 469, and there are also longitudinal anastomoses between similar branches in successive segments. These longitudinal anastomoses may become large and important, producing, for example, the anterior spinal artery; Hochstetter has shown that the vertebral arte is one of these longitudinal anastomoses between the seven cervical arteries which unite and th lose all but one of the connections with the aorta, and Mall has shown (see fig. 470) that the internal mammary and epigastric arteries are the united ends of the thoracic and lumbar arteries, their multiple connection with the aorta persisting in anastomoses with the intercostal arteries.

The cervical segmental arteries become most changed, owing to the shifting of the heart and the aorta, most of them, indeed, disappearing. The seventh remains as the stem of the vertebral and the distal portion of the subclavian. The head and neck have a double blood supply—first from the cervical segmental branches, and secondly from the branches of the aortic arches.

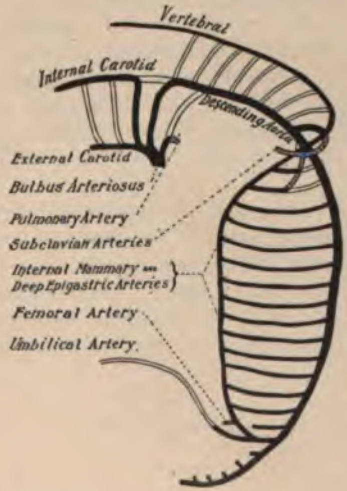
Fig. 469.—Scheme of the Typical Arrangement of the Branches of the Aorta. (After Quain.)


Posterior branch
Anterior branch
AO
SOMATIC
RENAL
SPLANCHNIC
Lateral perforating branch
INTESTINE
CŒLOM
Anterior perforating branch

The arteries of the limbs are, for the most part, the lateral perforating branches of segmental arteries. The proximal part of the right subclavian is, however, derived from the fourth branchial arch vessel (see p. 509). In comparing the arteries of the limbs it will be observed that the brachial artery divides into two branches, the radial and ulnar, which pass to the hand, and there make superficial and deep arches. In the leg, however, the popliteal has only one branch that enters into the plantar arches of the foot, namely, the posterior tibial. The peroneal and anterior tibial arteries correspond with the interossei of the arms, but there is no branch in the leg corresponding with the ulnar artery. On the dorsum of the foot the arches between the anterior tibial

Fig. 470.—Diagram to Show the Development of the Arteries of the Trunk from the Aortic Arches and Segmental Arteries.

The arteries which persist are black; those which degenerate are in outline; those newly formed are shaded. (After Mall.)


Vertebral
Internal Carotid
Descending Aorta
External Carotid
Bulbus Arteriosus
Pulmonary Artery
Subclavian Arteries
Internal Mammary and Deep Epigastric Arteries
Femoral Artery
Umbilical Artery

and perforating peroneal are both tarsal and metatarsal, while the corresponding arch in the hand is only carpal.

All these differences depend upon differences in development. Starting with a single artery. the anterior interosseous and peroneal, additional vessels have developed in each limb in a somewhat different manner. But the most striking difference is found in the fact that the main artery of the arm, the brachial, is upon the flexor (præaxial) surface, while that of the leg, the femoral, is on the extensor (post-axial). There is evidence, however, to show that this difference is secondary, the original main vessel of the thigh being on the flexor surface. It is represented in the adult by the inferior gluteal and its branch, the comes nervi ischiadici, and originally extended down the back of the thigh to join the popliteal. The femoral at this time was quite small and was represented mainly by the profunda femoris. Later, however, its superficial branch developed, and made a connection through the adductor magnus with the popliteal, whereupon the sciatic, as the original posterior artery was called, began to degenerate and the femoral became the principal vessel of the thigh.

The **splanchnic arteries** are divided into two sets, **unpaired ventral** branches, which enter the mesentery and supply the alimentary canal and the structures derived from it, and **paired lateral** branches, that supply the kidneys, adrenal bodies, and reproductive organs. The ventral branches were probably originally paired. They consist of small œsophageal and bronchial branches, and three large branches in the abdomen, the cœliac artery, and the superior and inferior mesenteric arteries. The formation of the three branches for the entire alimentary canal in the abdomen has probably resulted from the fusion of several segmental arteries. The cœliac artery supplies the first part of the canal in the abdomen and the glands that develope from it, and along the lesser curvature of the stomach its branches form a longitudinal ventral anastomosis, but throughout the rest of the digestive tract the anastomotic loops are formed only on the dorsal side. The hepatic and pancreatic arteries are branches of the gastro-duodenal artery, indicating the origin of both glands from the duodenum. The splenic artery is primarily gastric.

The superior mesenteric artery supplies the greater part of the intestine and develops from the omphalo-mesenteric artery. The inferior mesenteric supplies the hind gut, except the lowest portion of the rectum, which is supplied from branches which were primarily visceral, but have secondarily shifted their origin from the aorta to a somatic artery.

The paired visceral branches have also been reduced in number. They are intermediate in type between the somatic and unpaired splanchnic forms.

THE VEINS

The **veins,** like the arteries, are divided into two systems, the pulmonary and the systemic.

The **pulmonary** return the aërated blood from the lungs to the left side of the heart, and are the only veins that contain arterial blood. The **systemic veins** bring back to the right side of the heart the impure venous blood from the rest of the body. All the systemic veins terminate ultimately either in the superior or the inferior vena cava, except the cardiac veins, which return the blood from the heart's substance, and open directly into the right atrium.

The veins from the stomach and intestines, the spleen, and the pancreas, before opening into the inferior vena cava, are collected into a large trunk vein called the **portal vein,** which breaks up, like an artery, into capillaries in the substance of the liver. From these capillaries the blood is again collected by the hepatic veins, which finally open, as two or more large-sized vessels, into the inferior vena cava.

The veins show certain well-marked characteristics, which distinguish them from the arteries. The primitive venous trunks, as will be shown later (p. 675), do not follow the arteries, and the superficial veins, which develope early from the primitive trunks, also pursue courses which are, for the most part, independent of those followed by the arteries, as is seen, for example, in the cases of the cephalic, basilic, and saphenous veins of the arms and legs; and in that of the venous plexus over the surface of the body.

On the other hand, the deep veins, excepting some of those developing from the primitive trunks, for example, the two venæ cavæ, do follow the arteries. The very large veins which accompany arteries, such as the axillary and femoral, are single, while the medium-sized venæ comites are more commonly double. The number and relations of the venæ comites vary greatly, and the different veins have their own characteristic forms. For example, compare the double venæ comites of the arteries of the arm and leg with the plexus following the uterine artery. The veins of the brain form an exception to the rule that the deep veins follow the arteries, for the main cerebral arteries are at the base of the brain, while the large veins collect into sinuses on the convex surface.

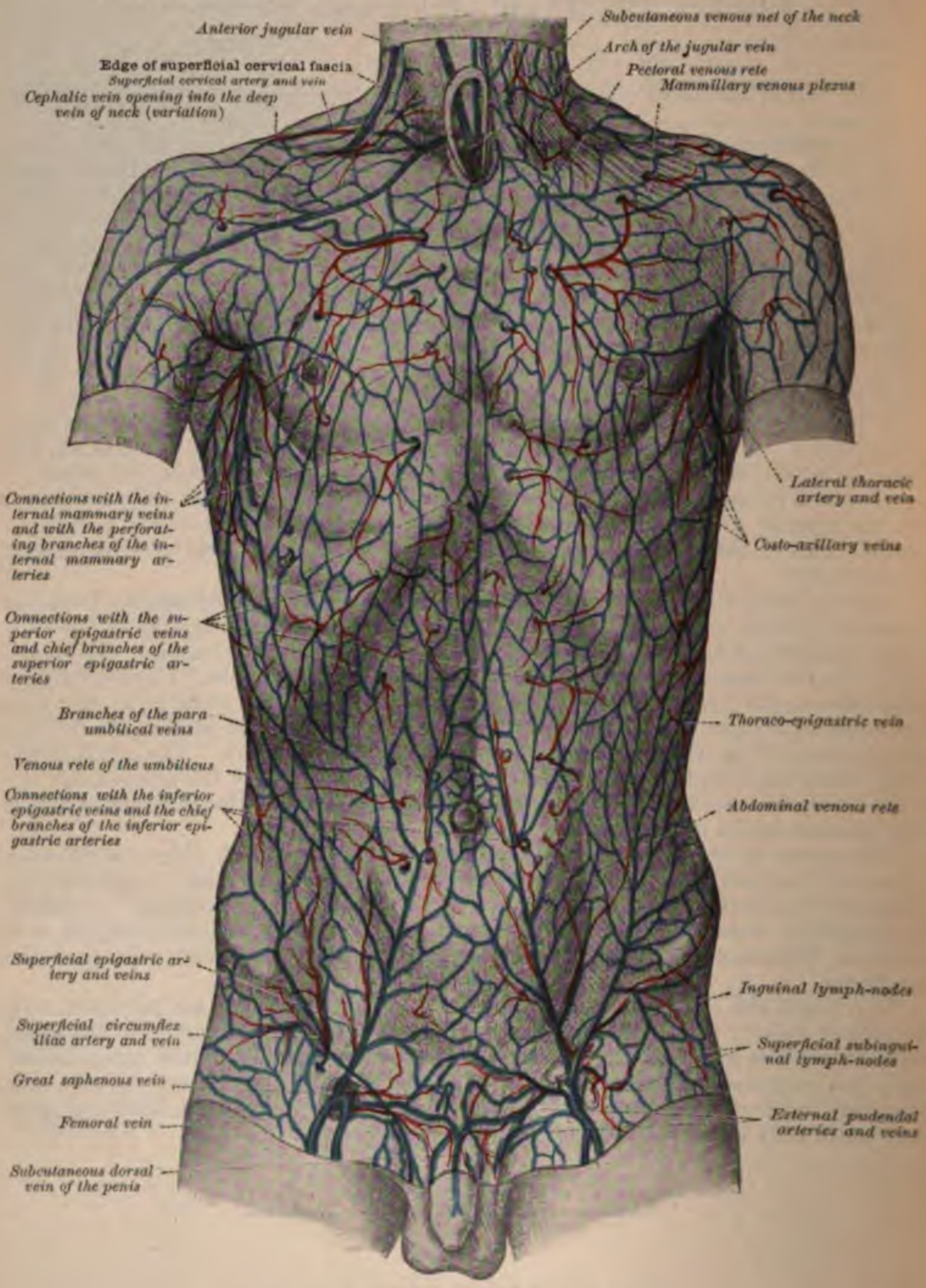
The veins have many more anastomoses than the arteries, these anastomoses occurring frequently with veins of all sizes from the greatest down; even the two venæ cavæ are connected by the azygos vein. Venæ comites are usually abundantly connected by cross branches; while in many instances in the venous system there is a plexus formation (fig. 471). In the arteries a plexus occurs only very near the capillaries.

The veins also differ from the arteries in that many of them are provided with semilunar valves, whose free borders are directed towards the heart. In the small veins the valves are single; in the larger veins they are usually double, rarely treble. They are irregularly distributed, being most numerous in the veins of the skin and the deep veins of the extremities, while in many of the veins of the head and neck they occur only where the veins open into the larger ones.

THE PULMONARY VEINS

The **pulmonary veins** (fig. 399) return the aërated blood from the lungs to the heart. They are usually four in number, two right and two left. Occasionally, however, there are three pulmonary veins on the right side, the result of the vein from the middle lobe of the right lung opening separately into the left atrium instead of joining as usual the upper of the two right pulmonary veins. The relations of the pulmonary veins to the pulmonary arteries and bronchi in the lungs are given with

FIG. 471.—THE SUBCUTANEOUS ARTERIES AND VEINS OF THE ANTERIOR BODY WALL. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Anterior jugular vein
Edge of superficial cervical fascia
Superficial cervical artery and vein
Cephalic vein opening into the deep vein of neck (variation)
Subcutaneous venous net of the neck
Arch of the jugular vein
Pectoral venous rete
Mammillary venous plexus
Connections with the internal mammary veins and with the perforating branches of the internal mammary arteries
Connections with the superior epigastric veins and chief branches of the superior epigastric arteries
Branches of the para umbilical veins
Venous rete of the umbilicus
Connections with the inferior epigastric veins and the chief branches of the inferior epigastric arteries
Superficial epigastric artery and veins
Superficial circumflex iliac artery and vein
Great saphenous vein
Femoral vein
Subcutaneous dorsal vein of the penis
Lateral thoracic artery and vein
Costo-axillary veins
Thoraco-epigastric vein
Abdominal venous rete
Inguinal lymph-nodes
Superficial subinguinal lymph-nodes
External pudendal arteries and veins

the ANATOMY OF THE LUNGS. At the root of the lung the pulmonary veins on both sides are arranged as an upper and a lower branch, an anterior descending branch of the bronchus passing between them. The upper vein on the right side is larger than the lower, and usually receives the vein from the middle lobe of the right lung. The lower vein on the left side is larger than the upper. Both the upper and lower veins lie in front of the pulmonary artery and on a lower plane, and run almost horizontally inwards and forwards to the left auricle. As they pierce the pericardium they receive a reflexion from the serous layer of that membrane. Their relations within the pericardium are given with the ANATOMY OF THE HEART. At the root of the lung their relations to the surrounding structures are similar to those of the pulmonary arteries (pp. 503 and 504).

THE SYSTEMIC VEINS

The **systemic veins** are naturally divided into three groups—(1) the veins of the heart; (2) the veins which empty into the superior vena cava, namely, those of the head, neck, arm, and thorax; and (3) the veins which empty into the inferior vena cava, namely, the portal system, and the veins of the abdomen, pelvis, and legs.

I. THE VEINS OF THE HEART

The veins of the heart have already been described (p. 496).

II. VEINS EMPTYING INTO THE SUPERIOR VENA CAVA

THE SUPERIOR VENA CAVA

The **superior** or **descending vena cava** (fig. 472) carries to the heart the blood returned from the head and neck and upper extremities through the right and left innominate veins, and from the walls of the thorax, either directly through the azygos vein, or indirectly through the innominate veins. It is formed (fig. 472) by the confluence of the right and left innominate veins at the lower border of the first right costal cartilage close to the sternum, and, descending from this spot in a gentle curve with its convexity to the right and in a direction slightly backwards and outwards behind the sternal end of the first and second intercostal spaces and second costal cartilage, terminates in the right auricle of the heart on a level with the third right costal cartilage in front and the seventh thoracic vertebra behind. It measures about 7 to 8 cm. (3 in.) in length. A little more than its lower half (4 cm.) is contained within the pericardium, the serous layer of that membrane being reflected obliquely over it immediately below the spot where it is joined by the vena azygos, and on a lower level than the reflexion of the pericardium on the aorta. The superior vena cava contains no valves.

Relations.—**In front,** in addition to the first and second intercostal spaces and the second costal cartilage, it is covered by the remains of the thymus gland, the intrathoracic fascia, and the pericardium, and is overlapped by the right pleura and lung.

Behind (fig. 472) are the vena azygos (major), the right bronchus, the right pulmonary artery, and the superior right pulmonary vein; and below, the fibrous layer of the pericardium. The serous layer is reflected over the front and sides of the vessel, but not over its posterior part.

To the **right side** are the right lung and pleura and the phrenic nerve.

To the **left side** are the innominate artery and the first or ascending portion of the arch of the aorta.

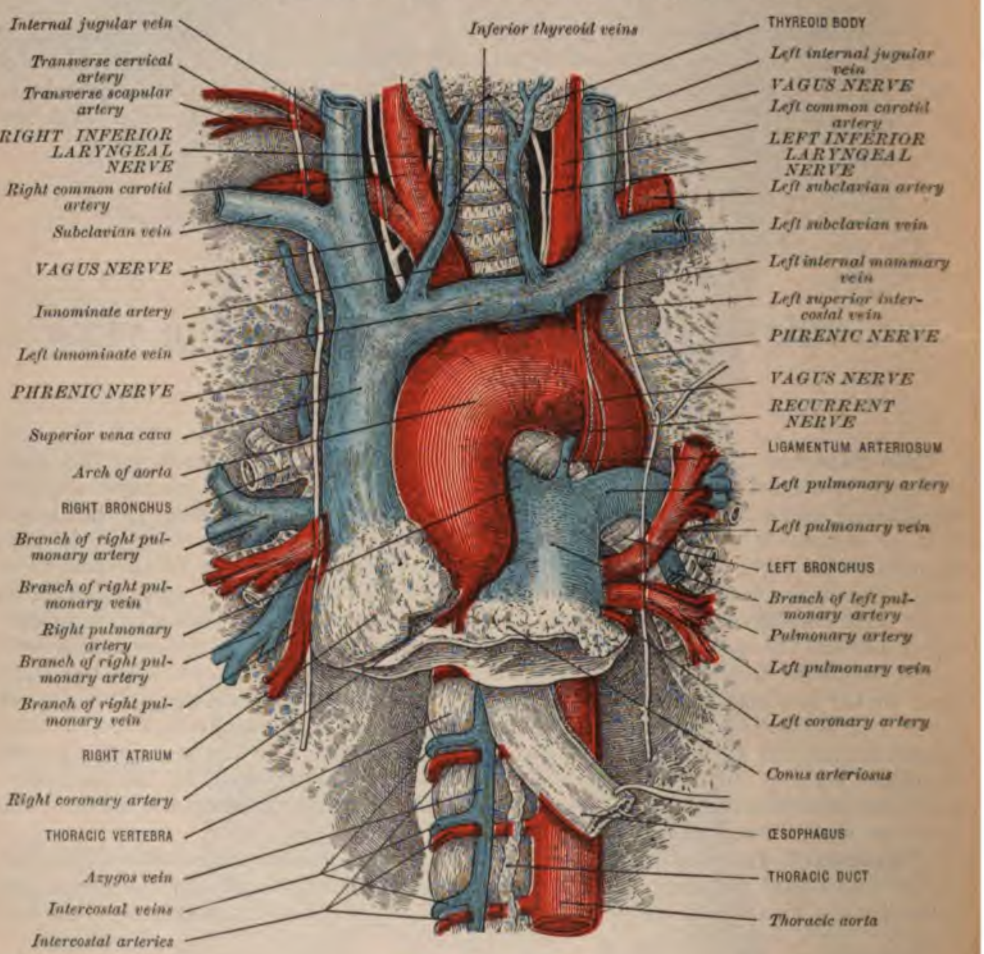
Tributaries.—In addition to the right and left innominate veins and the vena azygos it receives small veins from the mediastinum and pericardium.

THE INNOMINATE VEINS

The **innominate** or **brachio-cephalic veins** return the blood from the head and neck and upper extremity. They are formed on each side by the confluence of the internal jugular and subclavian veins behind the sternal end of the clavicle. They terminate at the lower border of the first costal cartilage on the right side by uniting to form the superior vena cava. The innominate veins have no valves.

The **right innominate vein** (fig. 472) measures about 2 to 3 cm. (1 to 1½ in.) in length, and descends from its origin behind the sternal end of the clavicle, very slightly forwards and inwards, along the right side of the subclavian and innominate arteries, to its junction with the left vein behind the first costal cartilage close to the sternum. It is superficial to the innominate artery.

Fig. 472.—The Vena Cava Superior and the Innominate Veins. (Modified from a dissection in St. Bartholomew's Hospital Museum.)


Internal jugular vein
Transverse cervical artery
Transverse scapular artery
RIGHT INFERIOR LARYNGEAL NERVE
Right common carotid artery
Subclavian vein
VAGUS NERVE
Innominate artery
Left innominate vein
PHRENIC NERVE
Superior vena cava
Arch of aorta
RIGHT BRONCHUS
Branch of right pulmonary artery
Branch of right pulmonary vein
Right pulmonary artery
Branch of right pulmonary artery
Branch of right pulmonary vein
RIGHT ATRIUM
Right coronary artery
THORACIC VERTEBRA
Azygos vein
Intercostal veins
Intercostal arteries
Inferior thyreoid veins
THYREOID BODY
Left internal jugular vein
VAGUS NERVE
Left common carotid artery
LEFT INFERIOR LARYNGEAL NERVE
Left subclavian artery
Left subclavian vein
Left internal mammary vein
Left superior intercostal vein
PHRENIC NERVE
VAGUS NERVE
RECURRENT NERVE
LIGAMENTUM ARTERIOSUM
Left pulmonary artery
Left pulmonary vein
LEFT BRONCHUS
Branch of left pulmonary artery
Pulmonary artery
Left pulmonary vein
Left coronary artery
Conus arteriosus
ŒSOPHAGUS
THORACIC DUCT
Thoracic aorta

Relations.—In front are the origins of the sterno-hyoid and sterno-thyreoid muscles, the clavicle, the first costal cartilage, and the remains of the thymus gland.

Behind are the pleura and lung.

To the **right** are the right pleura and lung and the phrenic nerve.

To the **left** (fig. 472) are the right subclavian artery, the innominate artery, the right vagus nerve, and the trachea.

The **left innominate vein** (fig. 472) measures 6 to 7·5 cm. (2½ to 3 in.) in length, and extends from its origin behind the sternal end of the left clavicle obliquely across the three main branches of the arch of the aorta, to unite with the right innominate vein at the lower border of the cartilage of the first rib close to the sternum to form the vena cava superior. In this course it runs from left to right with an inclination downwards and slightly backwards. A line drawn obliquely across the upper half of the manubrium of the sternum, from the sterno-clavicular articulation on the left side to the lower border of the first costal cartilage at its junction with the sternum on the right side, will indicate its course. The left innominate vein is on a level with the top of the sternum at birth.

Relations.—In front, in addition to the manubrium of the sternum, it has the origins of the sterno-hyoid and sterno-thyreoid muscles, and the remains of the thymus gland, the sternal end of the left clavicle, and the sterno-clavicular articulation.

Behind are the three chief arteries arising from the arch of the aorta, the trachea, and the left phrenic and left vagus nerves.

Below it is the transverse portion of the arch of the aorta.

Above it are the cervical fascia and inferior thyreoid veins.

Tributaries.—In addition to the internal jugular and subclavian veins, by the confluence of which the innominate veins are formed, each vein receives on its upper aspect the vertebral, the deep cervical, inferior thyreoid, and thyreoidea ima veins; and on its lower aspect the internal mammary vein. The left vein, moreover, is joined by the left superior intercostal, and by the thymic, mediastinal, and pericardiac veins. At the confluence of the internal jugular and subclavian veins on the right side the three lymphatic trunks or the right lymphatic duct open; on the left side the thoracic duct.

The Development of the Superior Vena Cava

At an early stage of development two veins, the jugulars, descend the neck towards the heart, and are joined by the two subclavian veins. Shortly before reaching the atrium of the heart each vein is joined by a vein (the cardinal) ascending from below, and the common stem thus formed upon each side, and known as the ductus Cuvieri, extends directly inwards to open independently into the right atrium. At a later period a cross branch extends from the left jugular to the right to form the left innominate vein of the adult, and the lower part of the right jugular and the right ductus Cuvieri become the superior vena cava. The portion of the left jugular below the origin of the left innominate then normally partly disappears, its lower portion becoming converted into the oblique vein of the left atrium, while the left ductus Cuvieri persists as the coronary sinus.

Chief Variations in the Superior Vena Cava and Innominate Veins

The variations in the vena cava and innominate veins depend upon abnormalities in the development of the great veins. They may be classified as follows:—

(1) *Variations due to the Persistence of the Left Duct of Cuvier*

(*a*) The left subclavian may join the left internal jugular vein to form a trunk which is continued almost vertically downwards over the arch of the aorta in front of the root of the left lung, to open into the coronary sinus of the heart. This variety is known as the persistent left superior vena cava, and is the persistence of the primitive embryonic arrangement.

When the so-called left superior vena cava is present, the accessory hemiazygos vein (the remains of the upper part of the left cardinal vein) may open into it by arching over the root of the left lung in a way similar to that in which the azygos (the right cardinal vein) opens into the superior vena cava over the root of the right lung. The normal left innominate vein may be absent, or may be quite small or rudimentary.

(*b*) A vein may run from the left innominate, or left superior intercostal vein, through the vestigial fold of the pericardium to the coronary sinus, the left innominate vein being itself normal. This abnormality is similar in kind, but minor in degree, to the former, described under (*a*).

(2) *Variations due to Persistence of the Left and Suppression of the Right Duct of Cuvier*

(*a*) The right innominate vein may cross the arch of the aorta to join a vertical left innominate vein, and thus form a left superior vena cava, the normal right superior cava being absent. The arrangement of the azygos veins under this condition may be reversed, there being a left vena azygos opening over the root of the left lung into the left superior cava, and a right hemiazygos and accessory vein arranged after the manner of the normal left azygos veins. This arrangement of the veins may occur independently of any general transposition of the viscera.

(*b*) There are many other varieties, depending upon abnormalities in the normal development of the great veins from the Cuvierian ducts and from the primitive jugular and cardinal veins; but these cannot be discussed here.

THE VEINS OF THE HEAD AND NECK

The **veins of the head and neck** may be divided for purposes of description into the **superficial,** which return the blood from the external parts of the head and neck; and the **deep,** which return the blood from the deeper structures. The **superficial** may be again subdivided, according to the region from which they carry the blood, into:—(1) The veins of the scalp and face; and (2) the veins of the neck. The **deep veins**—into which, moreover, some of the superficial open—may be subdivided into:—(1) The veins of the diploë; (2) the venous sinuses; (3) the veins of the brain; (4) the veins of the nasal cavities; (5) the veins of the ear; (6) the veins of the orbit; (7) the veins of the pharynx and larynx; and (8) the deep veins of the neck. All the veins, whether superficial or deep, sooner or later terminate in the internal jugular, the external jugular, the vertebral, or the deep cervical vein—chiefly the two former; and these veins open directly or indirectly into the innominate veins at the root of the neck, through which all the blood from the head and neck ultimately passes on its way to the heart.

THE SUPERFICIAL VEINS OF THE HEAD AND NECK

1. THE SUPERFICIAL VEINS OF THE SCALP AND FACE

The blood from the scalp is returned by four main channels—two for the front of the head, the anterior (facial) and posterior facial (temporo-maxillary), and two for the back of the head, the posterior auricular and the occipital. These veins empty partly into the superficial veins of the neck and partly into the deep. The anterior facial joins the common facial, which empties into the internal jugular vein. The posterior facial divides into two branches at the angle of the jaw; one of these joins the anterior facial to make the common facial, and so passes to the internal jugular vein, while the other joins the external jugular vein. The posterior auricular vein joins the external jugular, while the occipital veins end in the external jugular or deep cervical vein.

A. The Anterior Facial Vein

The **anterior facial vein** has a long course and changes its name according to the region in which it lies. It descends near the middle line, over the frontal bone, to the inner angle of the orbit; continues its course by the side of the nose to the cheek, which it crosses obliquely, to the anterior edge of the masseter muscle, and thence passes through the digastric triangle to the upper border of the hyoid bone, where it terminates in the internal jugular vein. In this course it is reinforced by numerous collateral veins, and gradually increases in size. It has, moreover, numerous communications with the deep veins.

As it descends over the frontal bone it is known as the **frontal vein;** as it lies by the side of the nose it is called the **angular vein;** whilst in the remainder of its course over the face and neck it is spoken of as the **anterior facial vein.**

(1) The **frontal vein** begins about the level of the coronal suture in a venous plexus which communicates with the anterior division of the temporal vein. Soon forming a single trunk, it passes vertically downwards over the frontal bone, a short distance from the middle line and parallel to its fellow of the opposite side, to the inner canthus of the eyelids, where it takes the name of the angular vein (fig. 473).

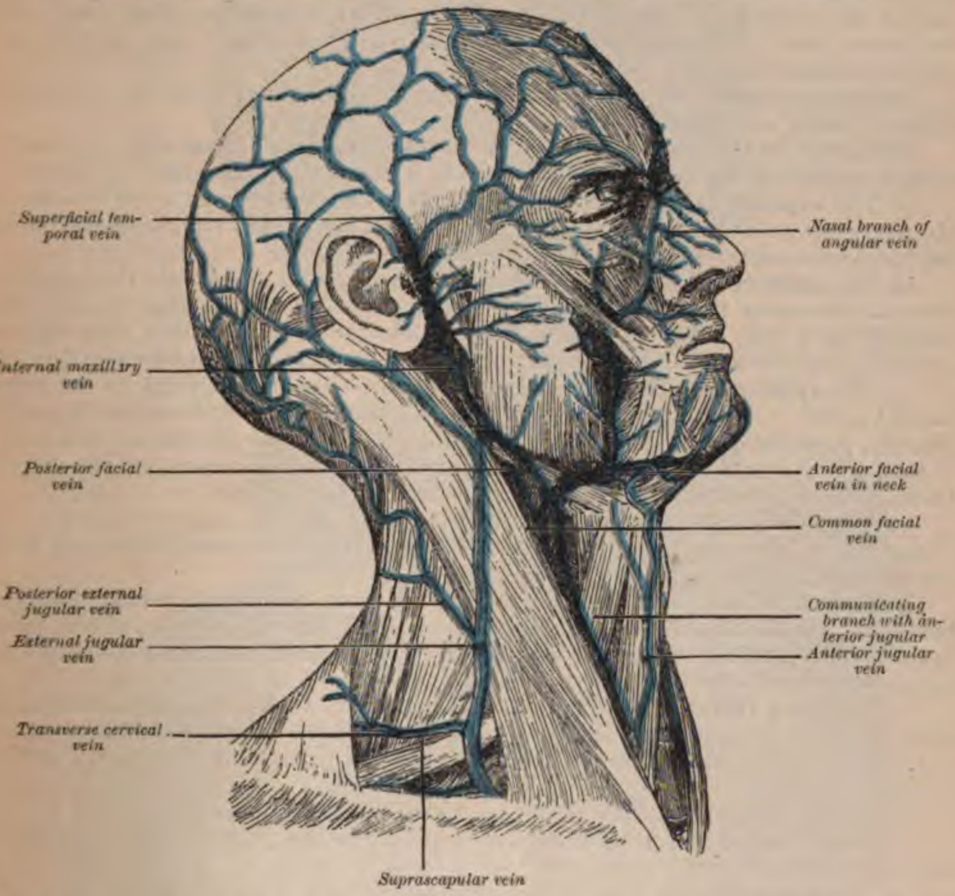
Tributaries.—In its course it receives numerous tributaries from the forehead, and communicates freely with the vein of the opposite side, across the glabella or root of the nose, by a transverse branch sometimes called the **transverse nasal vein.** Just before its termination it receives the supraorbital vein. The transverse nasal vein usually receives the dorsal veins of the nose.

The **supraorbital vein** begins over the frontal eminences by intercommunications with the middle temporal vein. It receives tributaries from the forehead and eyebrow, and, running obliquely downwards and inwards, opens into the terminatio of the frontal vein. It communicates with the ophthalmic vein, and receives t frontal vein of the diploë as the latter vein issues from the bone at the bottom of the supraorbital notch.

(2) The **angular vein,** the continuation of the frontal vein downwards, extends from the junction of the frontal and supraorbital veins a little below the level of the eyebrow, to the level of the lower margin of the orbit, where it becomes the anterior facial vein. In this short course it skirts around the inner margin of the orbit, lying with the angular artery on the frontal (nasal) process of the maxillary bone a little internal to the lachrymal sac. Branches pass from the posterior part of the angular vein into the orbit to join the ophthalmic.

The angular, the facial, and the ophthalmic veins contain no valves. The blood, therefore, can pass either forwards from the ophthalmic into the angular, or backwards through the facial and angular into the ophthalmic, and so on to the cavernous and other venous sinuses of the cranium. Hence in certain tumours in the orbit and cranium, the congestion of the angular and facial veins; and the danger in facial carbuncle and anthrax of septic thrombi spreading backwards through the angular and ophthalmic veins to the cranial sinuses.

Fig. 473.—The Superficial Veins of the Face and Scalp. (After Quain.)


Superficial temporal vein
Internal maxillary vein
Posterior facial vein
Posterior external jugular vein
External jugular vein
Transverse cervical vein
Suprascapular vein
Nasal branch of angular vein
Anterior facial vein in neck
Common facial vein
Communicating branch with anterior jugular
Anterior jugular vein

Tributaries.—(*a*) The superior external nasal; and (*b*) the palpebral veins.

(*a*) The **superior external nasal veins** ascend from the ala and the side of the nose to join the inner side of the angular vein (fig. 473).

(*b*) The **palpebral veins** proceed from the upper and lower eyelids, and open into the outer side of the angular vein, either separately or by a common trunk. Several branches of the inferior palpebral vein open into the anterior facial vein (*fig.* 473).

(3) The **anterior facial vein,** the continuation of the angular, begins at the lower margin of the orbit, and, crossing the face obliquely downwards and outwards, passes

at the anterior edge of the masseter muscle over the body of the lower jaw, and thence downwards and backwards across the digastric and superior carotid triangles to join the internal jugular vein about the level of the hyoid bone. It runs in a more or less direct line behind its corresponding artery, the external maxillary (facial), which itself pursues a tortuous course. It usually passes beneath the zygomatic muscles and beneath the platysma, but above the other muscles. At the anterior edge of the masseter it meets the external maxillary (facial) artery, lying immediately posterior to it. In the neck it lies beneath the platysma and cervical fascia, and is usually separated from the external maxillary (facial) artery by the submaxillary gland and the stylo-hyoid and posterior belly of the digastric muscles, below which it usually receives a communicating branch from the posterior facial vein. That portion of the vein from the spot where it receives the communicating branch to its termination in the internal jugular is the **common facial vein.**

Tributaries.—It receives on its **inner side,** from above downwards:—(*a*) The inferior external nasal veins; (*b*) the superior labial vein; (*c*) the inferior labial veins; (*d*) the submental vein; (*e*) the submaxillary veins. On the **outer side**:—(*a*) the inferior palpebral veins; (*b*) the deep facial (anterior internal maxillary) vein; (*c*) the buccal vein; (*d*) the anterior parotid vein; (*e*) the masseteric vein; and (*f*) the inferior palatine vein.

Communications.—It communicates with the infraorbital vein, the pterygoid plexus of veins, and the anterior jugular vein.

Tributaries on the Inner Side.—(*a*) The **inferior external nasal vein** is a small branch which joins the anterior facial on a level with the ala of the nose.

(*b*) The **superior labial vein** begins as a plexus in the orbicularis oris muscle of the upper lip, passes with the superior labial (coronary) artery outwards, and joins the facial vein a little below the level of the ala of the nose.

(*c*) The **inferior labial veins.**—A small branch usually opens into the anterior facial a little below the superior labial vein; but the chief branch from the lower lip descends as a rule over the chin to the submental vein, and thus only opens indirectly into the anterior facial vein. It may open into the anterior jugular vein.

(*d*) The **submental vein** lies on the mylo-hyoid muscle superficial to the submental artery. It begins below the chin, and, running backwards in the digastric triangle, joins the anterior facial vein just after the latter has passed over the body of the lower jaw. It receives branches from the inferior labial plexus and the neighbouring muscles, and communicates with the anterior jugular vein.

(*e*) The **submaxillary** or **glandular veins** open into the anterior facial as it crosses the submaxillary gland. But some branches from the gland often open into the submental vein.

Tributaries on the Outer Side.—(*a*) The **inferior palpebral veins.**—Several branches pass downwards to the anterior facial vein; others, as before stated, pass inwards to the angular vein. Through one or more of these branches a communication is formed with the infraorbital vein.

(*b*) The **deep facial** or **anterior internal maxillary vein** passes downwards and forwards from the pterygoid plexus of veins between the buccinator and masseter muscles, and opens into the outer side of the anterior facial vein under cover of the zygomaticus muscle.

(*c*) The **buccal vein** is a small branch from the buccinator muscle.

(*d*) The **anterior parotid branch** descends from the glandula socia parotidis forwards to the anterior facial.

(*e*) The **masseteric** is a small branch from the masseter muscle.

(*f*) The **inferior palatine vein** accompanies the ascending palatine or tonsillar artery from the venous plexus about the tonsil and soft palate, and joins the anterior facial vein just below the body of the lower jaw.

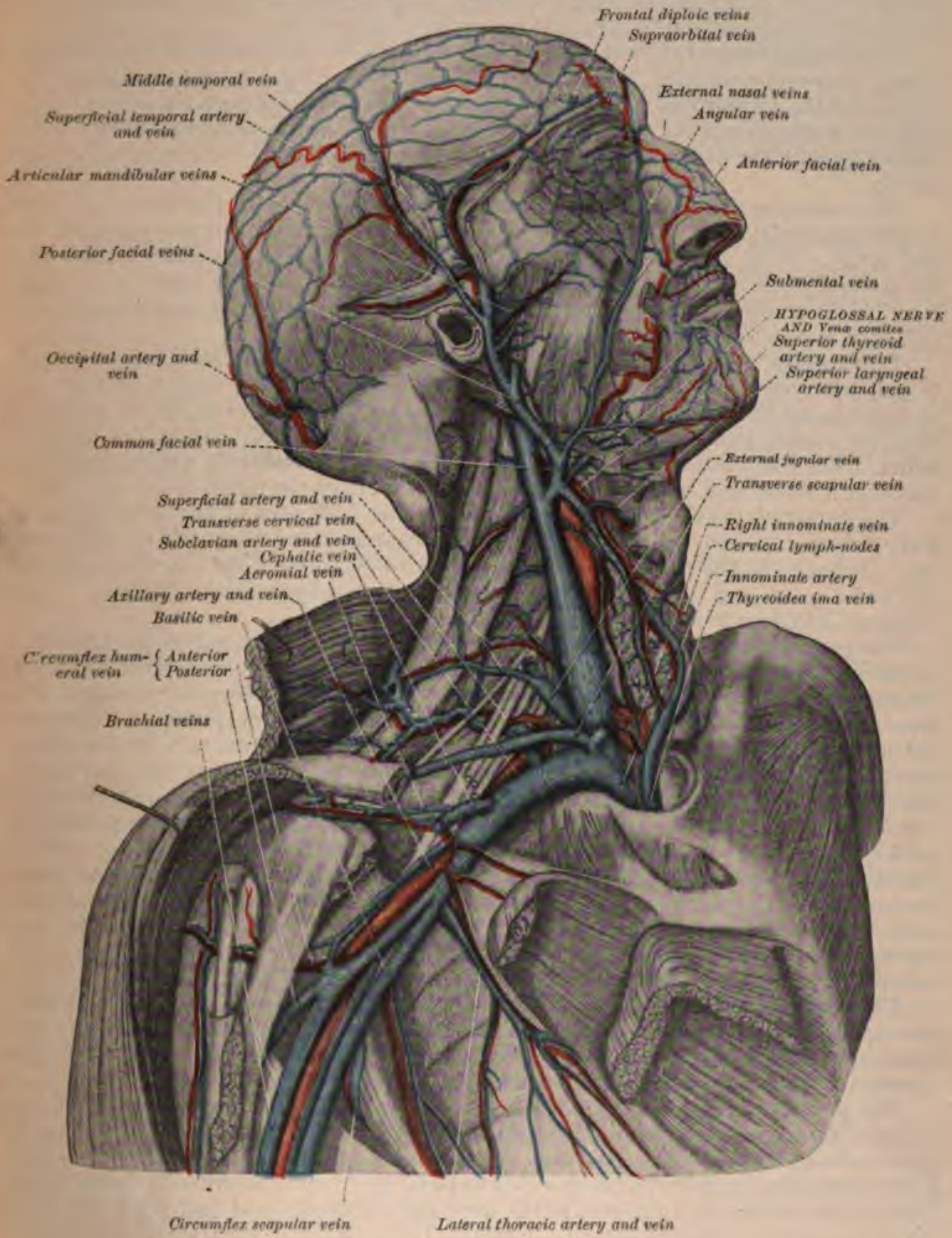
The **chief variations in the anterior facial vein** are:—(1) It may run over the sternomastoid and open into the external jugular vein; (2) it may open into the anterior jugular vein; (3) it may run beneath the posterior belly of the digastricus and stylo-hyoid muscles; (4) it may receive the lingual vein, the pharyngeal vein, or both of these veins.

B. The Posterior Facial (Temporo-maxillary) Vein

The **posterior facial** or **temporo-maxillary vein** is formed by the union of the temporal and internal maxillary veins.

The **temporal vein** is known as far as the zygoma as the **superficial temporal vein.** There it is joined by the **middle temporal vein;** and the united trunk, now called the **common temporal vein,** passes over the zygoma into the parotid gland. Opposite the neck of the lower jaw it receives the large **internal maxillary vein,** and takes the name of the **posterior facial vein.** This emerges from the lower border of the parotid gland and divides into two branches—one joins the anterior facial to form the common facial, while the other joins the posterior auricular, to form the external jugular vein.

Fig. 474.—The Veins' of the Head, Neck, and Axilla. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Frontal diploic veins
Supraorbital vein
Middle temporal vein
External nasal veins
Angular vein
Superficial temporal artery and vein
Articular mandibular veins
Anterior facial vein
Posterior facial veins
Submental vein
HYPOGLOSSAL NERVE AND Venæ comites
Superior thyreoid artery and vein
Occipital artery and vein
Superior laryngeal artery and vein
Common facial vein
External jugular vein
Transverse scapular vein
Superficial artery and vein
Transverse cervical vein
Subclavian artery and vein
Right innominate vein
Cephalic vein
Cervical lymph-nodes
Acromial vein
Innominate artery
Axillary artery and vein
Thyreoidea ima vein
Basilic vein
Circumflex humeral vein { Anterior
Posterior
Brachial veins
Circumflex scapular vein
Lateral thoracic artery and vein

The **superficial temporal vein** returns the blood from the parietal region of the scalp. It is formed by the union of an anterior and a posterior branch: the former communicates with the supraorbital and frontal veins; the latter with the posterior auricular and occipital veins and the temporal vein of the opposite side. These branches lie superficial to the corresponding branches of the superficial temporal artery, which they roughly though not accurately follow. Like the artery, they lie between the skin and the cranial aponeurosis, and descend over the temporal fascia to unite a little above the zygoma, and just in front of the pinna of the ear, to form the superficial temporal trunk. The vein thus formed continues its course downwards with the trunk of the temporal artery, and opposite the zygoma is joined by the middle temporal vein to form the common temporal vein.

The **middle temporal vein** corresponds with the orbital branch of the temporal artery, and communicates in front with the ophthalmic vein, the external palpebral veins, and the infraorbital veins, and then runs backwards between the layers of the temporal fascia to join the superficial temporal vein. The middle temporal vein communicates with the deep temporal veins, and through them with the pterygoid venous plexus.

The **common temporal vein,** formed by the confluence of the superficial and middle temporal veins, descends over the zygoma just in front of the pinna of the ear, lying a little superficial to the temporal artery. Then, passing deeply into the parotid gland, between the external auditory meatus and the angle of the jaw, it is joined almost at a right angle by the internal maxillary vein, and becomes the posterior facial (temporo-maxillary) vein.

Tributaries.—It receives (*a*) the **transverse facial vein,** which corresponds to the transverse facial artery; (*b*) **articular veins** from the plexus around the temporo-mandibular joint—this plexus receives the **tympanic vein,** which, together with its corresponding artery, passes through the fissure of Glaser; (*c*) **parotid veins,** from the substance of the parotid gland; (*d*) **masseteric veins,** from the masseter muscle; and (*e*) **anterior auricular veins,** from the pinna of the ear.

The **internal maxillary vein** accompanies the first part of the internal maxillary artery between the spheno-mandibular ligament and the neck of the lower jaw. It begins at the posterior confluence of the veins forming the pterygoid plexus, and ends by uniting with the common temporal vein to form the posterior facial (temporo-maxillary) trunk.

The **pterygoid plexus** is formed by the veins which correspond to the branches of the internal maxillary artery. It is situated, partly on the inner surface of the internal pterygoid muscle, and partly around the external pterygoid muscle. The veins entering into this plexus are:—the two **middle meningeal,** which accompany the artery of that name; the **posterior superior alveolar** (dental); the **inferior alveolar** (dental); the **masseteric;** the **buccal;** the **pterygoid veins** from the pterygoid muscles; the **deep temporal,** by which the plexus communicates with the temporal plexus; the **spheno-palatine vein;** the **infraorbital;** the **superior palatine;** the lower branch of the **ophthalmic vein,** which courses through the inferior orbital (spheno-maxillary) fissure; and the **rete foraminis ovalis** and **Vesalian vein,** through which the plexus communicates with the cavernous sinus. The plexus ends posteriorly in the internal maxillary vein, which joins the common temporal vein, and anteriorly in the deep facial vein, which passes forwards and downwards between the buccinator and masseter muscles to join the anterior facial vein.

The above-mentioned veins, forming by their confluence the pterygoid plexus, correspond in their course so nearly with that of their companion arteries that a detailed description is not necessary. Although for convenience described with the superficial veins, they are all deeply placed.

The **posterior facial** or **temporo-maxillary vein** is formed by the union of the common temporal vein and internal maxillary vein in the substance of the parotid gland. It usually divides into two branches, an anterior and a posterior. The anterior division runs forwards and downwards, and joins the anterior facial vein. The posterior division runs backwards over the sterno-mastoid and joins the posterior auricular to form the external jugular. Occasionally it joins, without dividing, the posterior auricular to form the external jugular vein, the anterior branch being then represented by a communicating branch between the external jugular and anterior facial veins.

C. The Posterior Auricular Vein

The **posterior auricular vein** begins in a venous plexus on the posterior part of the parietal bone. This plexus communicates with the vein of the opposite side across the sagittal suture, and with the posterior branch of the superficial temporal vein in front, and with the occipital vein behind. It descends over the back part of the parietal bone and the mastoid process of the temporal bone, lying with its artery behind the ear. It then leaves the artery, and passing over the upper part of the sterno-mastoid muscle obliquely forwards and downwards, joins the posterior facial vein about the level of the angle of the lower jaw, forming the external jugular vein (fig. 473).

Tributaries.—(*a*) Auricular veins from the back of the pinna; and (*b*) the stylo-mastoid vein, corresponding to the little stylo-mastoid artery. The latter vein opens into the posterior auricular vein, as a rule, as the latter leaves the mastoid process.

D. The Occipital Vein

The **occipital vein** begins at the back of the skull in a venous plexus which anastomoses with the posterior auricular and the posterior branch of the superficial temporal veins. It passes downwards over the occipital bone, and, perforating the trapezius with the occipital artery, opens into the internal jugular. At times, after perforating the trapezius, it sinks deeply into the suboccipital triangle and opens into the deep cervical vein; and at other times it takes a more superficial course, and, joining the posterior auricular, passes with this to the external jugular. One of its branches—usually the outermost—receives an emissary vein issuing through the mastoid foramen of the temporal bone, and in this way forms a communication with the transverse sinus.

2. THE SUPERFICIAL VEINS OF THE NECK

D. The External Jugular Vein

The **external jugular vein** (fig. 473) is formed by the confluence of the posterior auricular and posterior facial veins near the angle of the lower jaw. It runs obliquely downwards and backwards across the sterno-mastoid muscle to a point opposite the middle of the clavicle, where it terminates as a rule in the subclavian vein. A line drawn from a point midway between the mastoid process and angle of the jaw to the middle of the clavicle will indicate its course. It is covered by the skin, superficial fascia, and platysma, and is crossed by a few branches of the cervical plexus, the great auricular nerve running parallel to it at the upper part of the neck. It at first crosses the sterno-mastoid obliquely, then runs nearly parallel to the posterior border of that muscle, from which it is separated throughout its course by the anterior layer of the deep cervical fascia.

Just above the clavicle it perforates the cervical fascia, by which it is prevented from readily collapsing, the fascia being attached to its walls. It then opens into the subclavian vein, occasionally into the internal jugular, or into the confluence of the subclavian and internal jugular veins. It contains a pair of valves about 2·5 to 5 cm. (1 to 2 in.) above the clavicle, and a second pair where it enters the subclavian vein. Neither of these valves is sufficient to prevent the blood regurgitating, or injections passing from the larger vein into the external jugular.

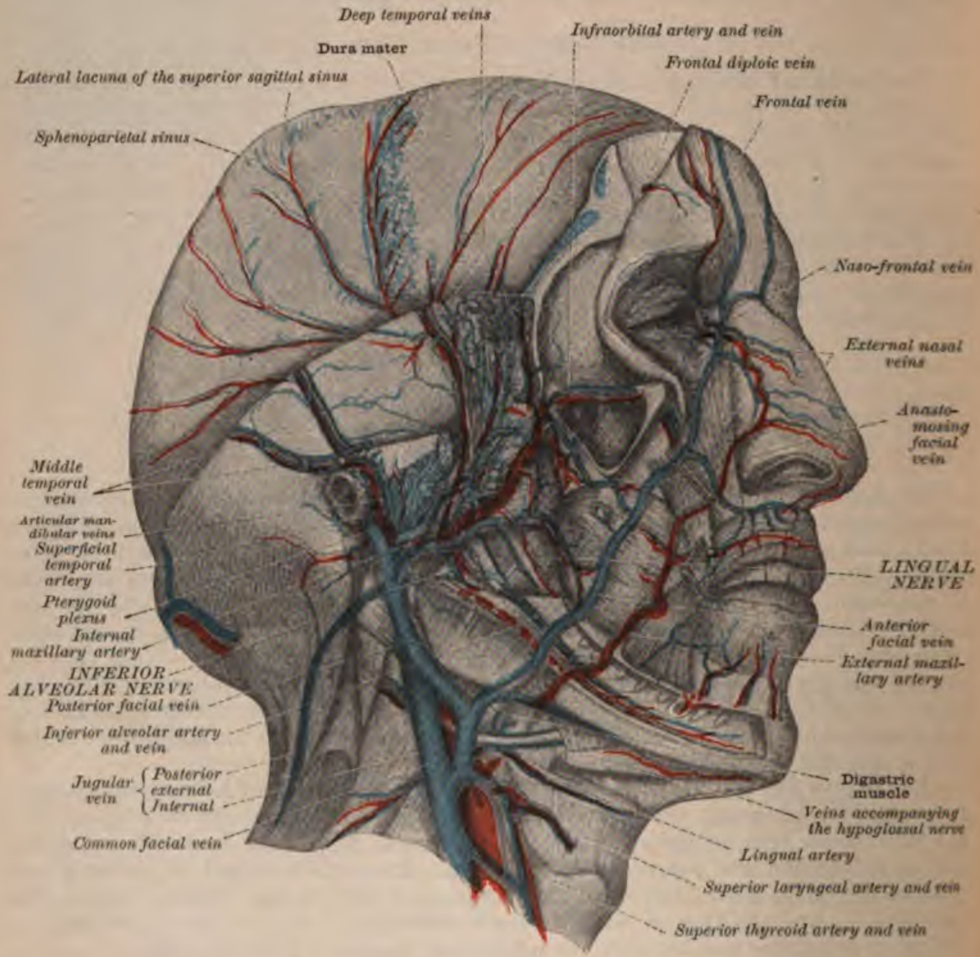
The **chief variations of the external jugular vein** are:—(1) It may be very small, or much smaller or much larger than the opposite vein; (2) it may be wanting on one or both sides, the veins which normally form it then opening into the internal jugular; (3) it may be formed merely by the posterior auricular vein; (4) it may be perforated by the cutaneus colli nerve; (5) it may receive the anterior facial, the lingual, and the cephalic veins; (6) it may pass over the clavicle and open into the cephalic or subclavian vein.

Tributaries and communications.—From above downwards, the external jugular receives a branch from the internal jugular vein; the **posterior external jugular,** which in the fœtus was part of the primitive jugular vein; a large branch connecting it with the facial vein; one or two small branches of communication from the anterior jugular vein; near its termination, the **transverse cervical**

and **transverse scapular** (**suprascapular**) **veins;** and sometimes the **anterior jugular vein,** at the posterior border and hinder surface of the sterno-mastoid. At times the occipital vein opens into the external jugular, and this by some anatomists is regarded as its normal termination.

The **posterior external jugular vein** descends from the upper and back part of the neck, receiving small tributaries from the superficial structures and muscles. At times it communicates with the occipital, or may appear as a continuation of that vein. It opens into the external jugular as the latter vein is leaving the sterno-mastoid muscle. In the fœtus this vein returns the blood from the interior of the cranium through the post-glenoid foramen. Vestiges of the fœtal trunk are said to remain in the mastoid vein.

FIG. 475.—THE VEINS OF THE FACE. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Deep temporal veins
Infraorbital artery and vein
Dura mater
Frontal diploic vein
Lateral lacuna of the superior sagittal sinus
Frontal vein
Sphenoparietal sinus
Naso-frontal vein
External nasal veins
Anastomosing facial vein
Middle temporal vein
Articular mandibular veins
Superficial temporal artery
LINGUAL NERVE
Pterygoid plexus
Internal maxillary artery
Anterior facial vein
External maxillary artery
INFERIOR ALVEOLAR NERVE
Posterior facial vein
Inferior alveolar artery and vein
Jugular vein
Posterior external
Internal
Digastric muscle
Veins accompanying the hypoglossal nerve
Common facial vein
Lingual artery
Superior laryngeal artery and vein
Superior thyreoid artery and vein

The **transverse scapular** (**suprascapular**) **veins,** two in number, correspond to the transverse scapular (suprascapular) artery. They usually form one trunk before they open into the external jugular vein. They contain well-marked valves.

The **transverse cervical veins**—or venæ comites of the transverse cervical artery—accompany that vessel and open with the transverse scapular (suprascapular) vein into the external jugular close to the spot where the latter vein joins the subclavian.

The **anterior jugular vein** begins below the chin by communicating with the mental, submental, inferior labial, and inferior hyoid veins. It descends a little external to the middle line, receiving branches from the superficial structures at the front and side of the neck, and occasionally a branch from the larynx and thyreoid body. Just above the clavicle it turns outwards, and, piercing the fascia, passes beneath the sterno-mastoid muscle and opens into the external jugular vein just before the latter joins the subclavian; at times it opens into the subclavian vein itself. In its course down the neck it communicates with the external jugular; and, as it turns outwards beneath the sterno-mastoid, sends a branch across the trachea, between the layers of cervical fascia, to join the anterior jugular of the opposite side. This communicating vein, the **jugular venous arch,** may be divided in the operation of tracheotomy, and is then often found greatly engorged with blood. Another branch, often of considerable size, courses along the anterior margin of the sterno-mastoid and joins the anterior facial vein. When the anterior jugular vein is large, the external jugular is small, and *vice versâ*. It is usually also of large size when the corresponding vein on the opposite side is absent, as is frequently the case. It contains no valves.

The position of the anterior jugular vein beneath the tendon of the sterno-mastoid should be borne in mind in tenotomy of that muscle for wry-neck.

THE DEEP VEINS OF THE HEAD AND NECK

The **deep veins of the head and neck** may be divided into:—(1) the veins of the diploë; (2) the venous sinuses of the cranium; (3) the veins of the brain; (4) the veins of the nasal cavities; (5) the veins of the ear; (6) the veins of the orbit; (7) the veins of the pharynx and larynx; and (8) the deep veins of the neck. The veins of the diploë terminate partly in the superficial veins already described, partly in the venous sinuses of the cranium, and partly in the deep veins of the neck. The venous sinuses open into the deep veins of the neck. The veins of the brain terminate in the venous sinuses. The veins of the nasal cavities terminate partly in the deep, and to some extent in the superficial veins. The veins of the ear join both the superficial and deep veins and the venous sinuses. The veins of the orbit terminate partly in the superficial veins, but chiefly in the venous sinuses. The veins of the pharynx and larynx enter the deep veins of the neck.

1. THE VEINS OF THE DIPLOË

The **veins of the diploë** (fig. 476) are contained in bony channels in the cancellous tissue between the external and internal tables of the skull. They are of comparatively large size, with very thin and imperfect walls, and form irregular communicating channels. They have no valves. They can only be seen on removing the external table of the skull with a file or chisel. They terminate in four or five main and descending channels, which open, some outwards through the external table of the skull into some of the superficial and deep veins of the head and face, and some inwards through the internal table into the venous sinuses. They are divided into the frontal, anterior temporal, posterior temporal, and occipital.

The **frontal** are contained in the anterior part of the frontal bone. They converge anteriorly to a single vein which passes downwards, perforates the external table through a small aperture in the roof of the supraorbital notch, and terminates in the supraorbital vein. They also communicate with the superior sagittal sinus.

The **anterior temporal** are contained in the posterior part of the frontal and in the anterior part of the parietal bone. They pass downwards, and end, partly in the deep temporal veins by perforating the greater wing of the sphenoid bone, and partly in the spheno-parietal sinus.

The **posterior temporal** ramifies in the parietal bone, and, coursing downwards to the posterior inferior angle of that bone, passes either through a foramen in its inner table, or through the mastoid foramen into the transverse sinus.

The **occipital** ramifies chiefly in the occipital bone, and opens into the occipital vein or into the transverse sinus.

The diploic veins freely anastomose with one another in the adult; but in the fœtus, before the bones have united, each system of veins is distinct.

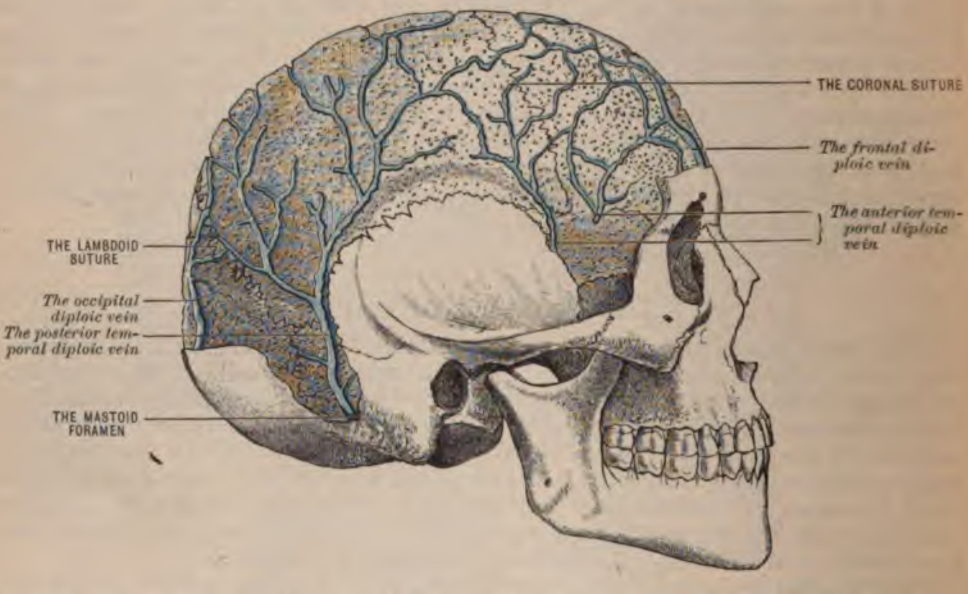
2. THE VENOUS SINUSES OF THE CRANIUM

The **venous sinuses of the cranium** are endothelially lined blood-spaces, situated between the periosteal and meningeal layers of the dura mater. They are the channels by which the blood is conveyed from the cerebral veins, and from some of the veins of the meninges and diploë, into the veins of the neck. The sinuses of the base of the skull also carry the chief part of the blood from the orbit and eyeball to the jugular veins. At certain spots the sinuses communicate with the superficial veins by small vessels known as the emissary veins, which run through foramina in the cranial bones.

The venous sinuses are sixteen in number, six being disposed medianly and singly; five laterally and in pairs. The median and single sinuses are:—(1) the superior sagittal; (2) the inferior sagittal; (3) the straight; (4) the occipital; (5) the circular; and (6) the basilar plexus. The lateral and paired sinuses are:—(7) the two transverse (lateral); (8) the two superior petrosal; (9) the two inferior petrosal; (10) the two cavernous; and (11) the two spheno-parietal. Occasionally there are two additional sinuses (the two petro-squamous), due to the persistence in the adult of what in the fœtus was the continuation of the transverse sinus.

(1) The **superior sagittal** or **longitudinal sinus** (fig. 478) lies in the median groove on the inner surface of the skull along the attached margin of the falx cerebri. It extends from the foramen cæcum to the internal occipital protuberance. It grooves from before backwards the frontal bone, the contiguous sagittal margins of the parietal bones, and the squamous portion of the occipital bone. In the fœtus it communicates, through the foramen cæcum, with the nasal veins, and generally throughout life with the superficial temporal vein through the parietal foramen. It is triangular on section, the base of the triangle corresponding to the bone. Crossing it are a number of fibrous bands known as the *chords of Willis*, and projecting into it in places are the Pacchionian bodies. In front the sinus is quite small, but it increases greatly in calibre as it runs backwards. It receives at intervals the superior cortical cerebral veins and the veins from the falx. The former, for the most part, open into it in the direction opposite to that in which the blood is flowing in the sinus. They pass for some distance in the walls of the sinus before opening into it. Posteriorly, at the internal occipital protuberance, the superior sagittal sinus usually turns sharply to the right, and ends in the right transverse (lateral) sinus; the straight sinus then usually terminates in the left transverse (lateral) sinus, and the right and

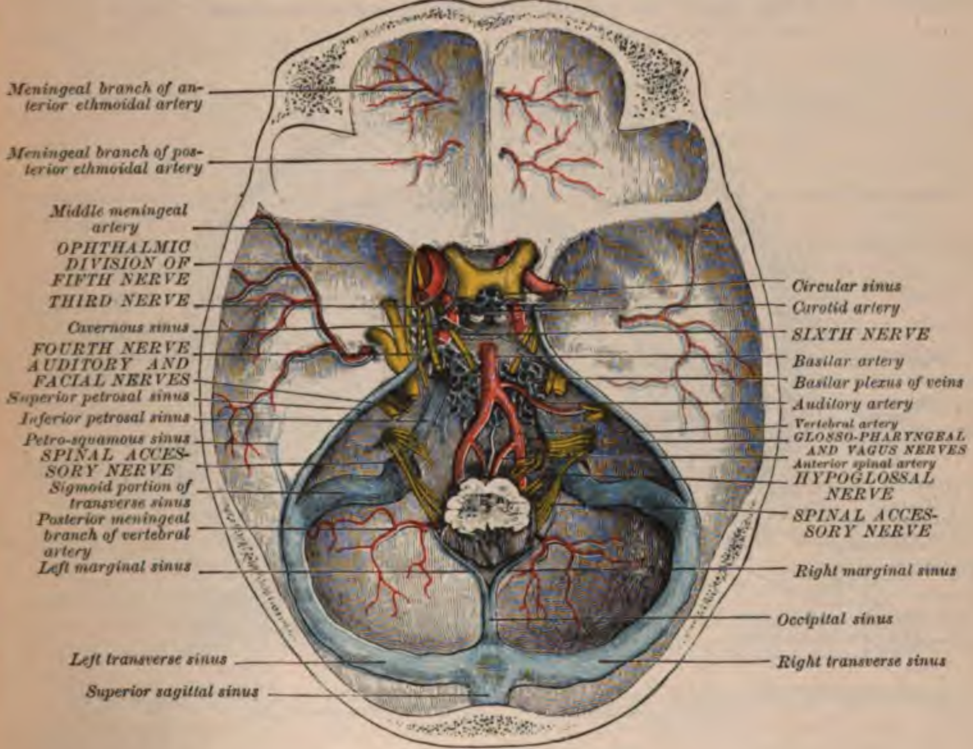
FIG. 476.—THE VEINS OF THE DIPLOË.
(From a specimen in St. Bartholomew's Hospital Museum.)


THE CORONAL SUTURE
The frontal diploic vein
The anterior temporal diploic vein
THE LAMBDOID SUTURE
The occipital diploic vein
The posterior temporal diploic vein
THE MASTOID FORAMEN

left transverse (lateral) sinuses communicate with each other across the occipital protuberance. Occasionally, however, the superior sagittal sinus ends in the left transverse (lateral) sinus, the straight then passing into the right. At other times the posterior end of the superior sagittal sinus at the internal occipital protuberance becomes slightly dilated, forming what is called the **torcular Herophili,** or confluence of the sinuses. When this dilatation exists, the straight sinus usually opens into it in front, the two transverse (lateral) sinuses, on either side, the superior sagittal above, the occipital sinus or sinuses, when two are present, below. The torcular may communicate with the occipital vein through the occipital emissary vein, which, when present, passes through a minute foramen in the occipital protuberance.

(2) The **inferior sagittal** or **longitudinal sinus** (fig. 478) is situated at the free margin of the falx cerebri. Beginning about the junction of the anterior with the middle third of the falx, it is continued backwards along the concave or lower margin of that process to the junction of the falx with the tentorium, where it ends in the straight sinus. The sinus is cylindrical in shape and of small size, and receives some of the inferior frontal veins of the brain, some of the veins from the median surface of the brain, and some of the veins of the falx.

Fig. 477.—The Venous Sinuses.
(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)


Meningeal branch of anterior ethmoidal artery
Meningeal branch of posterior ethmoidal artery
Middle meningeal artery
OPHTHALMIC DIVISION OF FIFTH NERVE
THIRD NERVE
Cavernous sinus
FOURTH NERVE
AUDITORY AND FACIAL NERVES
Superior petrosal sinus
Inferior petrosal sinus
Petro-squamous sinus
SPINAL ACCESSORY NERVE
Sigmoid portion of transverse sinus
Posterior meningeal branch of vertebral artery
Left marginal sinus
Left transverse sinus
Superior sagittal sinus
Circular sinus
Carotid artery
SIXTH NERVE
Basilar artery
Basilar plexus of veins
Auditory artery
Vertebral artery
GLOSSO-PHARYNGEAL AND VAGUS NERVES
Anterior spinal artery
HYPOGLOSSAL NERVE
SPINAL ACCESSORY NERVE
Right marginal sinus
Occipital sinus
Right transverse sinus

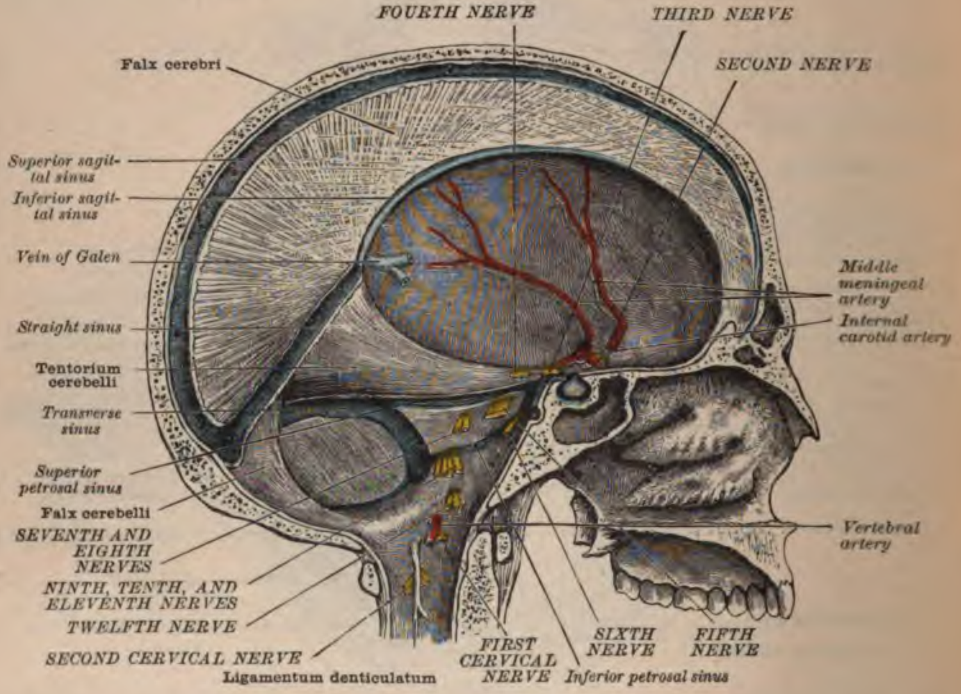
(3) The **straight sinus** lies along the junction of the falx cerebri with the tentorium cerebelli. It is formed by the union of the great cerebral vein of Galen and the inferior sagittal sinus. It receives in its course branches from the tentorium cerebelli and from the upper surface of the cerebellum. It runs downwards and backwards to the internal occipital protuberance, where it ends in the left transverse (lateral) sinus, at times in the right transverse (lateral) sinus, or in the torcular Herophili when that blood-space is present. On section it is triangular in shape, with its apex upwards.

(4) The **occipital sinus** (fig. 477) ascends mesially at the attached margin of the falx cerebelli, along the lower half of the squamous portion of the occipital

bone from near the posterior margin of the foramen magnum to the internal occipital protuberance. It usually begins in a right and a left branch, known as the **marginal sinuses.** These proceed from the termination of each transverse (lateral) sinus, run around the foramen magnum, where they communicate with the posterior spinal veins, and unite at a variable distance from the internal occipital protuberance to form the single occipital sinus. Sometimes they remain separate as far as the occipital protuberance, then forming two occipital sinuses. One or other of the marginal sinuses may be much smaller than the other, or be entirely absent. At the point where the marginal sinuses unite to form the single occipital sinus, there is a communication with the posterior spinal veins. The occipital sinus ends either in one of the transverse (lateral) sinuses, in the straight sinus, or in the torcular Herophili when this is present. It receives in its course veins from the tentorium cerebelli, and from the inferior surface of the cerebellum. It communicates through the plexus of veins which surrounds the hypoglossal nerve in the hypoglossal canal (anterior condyloid) with the vertebral vein and veins of the anterior spinal plexus.

(5) The **circular sinus,** so called (fig. 479), is a venous plexus encircling the hypophysis cerebri, and connecting the right and left cavernous sinuses.

FIG. 478.—THE VENOUS SINUSES. (Longitudinal section.)


FOURTH NERVE
THIRD NERVE
Falx cerebri
SECOND NERVE
Superior sagittal sinus
Inferior sagittal sinus
Vein of Galen
Middle meningeal artery
Straight sinus
Internal carotid artery
Tentorium cerebelli
Transverse sinus
Superior petrosal sinus
Falx cerebelli
Vertebral artery
SEVENTH AND EIGHTH NERVES
NINTH, TENTH, AND ELEVENTH NERVES
TWELFTH NERVE
FIRST CERVICAL NERVE
SIXTH NERVE
FIFTH NERVE
SECOND CERVICAL NERVE
Ligamentum denticulatum
Inferior petrosal sinus

(6) The **basilar plexus** is a venous plexus in the substance of the dura mater over the basilar process of the occipital bone. It extends from the cavernous sinus to the margin of the foramen magnum below. It communicates laterally with the inferior petrosal sinus, and inferiorly with the anterior spinal veins. Through this sinus passes the sixth nerve. One of the larger of the irregular venous channels forming the sinus passes transversely from one inferior petrosal sinus to the other. This venous plexus on the basilar process is serially homologous with the anterior spinal plexus of veins on the posterior surface of the bodies of the vertebræ.

(7) The **transverse** (or lateral) **sinus** (figs. 477 and 479) extends from the internal occipital protuberance to the jugular foramen. In this course it lies in the groove (which has been named after it) along the squamous portion of the occipital bone, the posterior inferior angle of the parietal bone, the mastoid portion of the temporal bone, and the jugular process of the occipital bone. It at first runs horizontally outwards and forwards between the two layers of the tentorium cerebelli, following the curve of the groove on the occipital and the posterior inferior

angle of the parietal bones. On reaching the groove in the mastoid portion of the temporal bone it leaves the tentorium and curves downwards and inwards and then forwards over the jugular process of the occipital bone, and ends in the posterior compartment of the jugular fossa in the **sinus jugularis** or bulb of the internal jugular vein. The S-shaped part of the sinus which lies on the mastoid portion of the temporal and jugular portion of the occipital bone is sometimes known as the **sigmoid sinus.** The transverse (lateral) sinus receives the veins from the temporal lobe of the cerebrum, some of the superior and inferior cerebellar veins, some of the veins of the medulla and pons, the occipital, and the external parietal veins of the diploë, and at the spot where it leaves the tentorium the superior petrosal sinus and, when present, the petro-squamous sinus. It communicates with the occipital and vertebral veins through the mastoid and posterior condyloid foramina by means of emissary veins. As the lateral sinus lies between the layers of the tentorium it is on section prismatic in shape. The sigmoid portion is semicylindrical.

The **right** transverse (lateral) sinus is usually the larger and the direct continuation of the superior sagittal sinus, and hence conveys the chief part of the blood from the cortical surface of the brain and vault of the skull. The **left** transverse (lateral) sinus is usually the smaller and the direct continuation of the straight sinus, and hence returns the chief part of the blood from the central ganglia of the brain.

The relation of the lateral sinus to the outside of the skull, especially to the mastoid process of the temporal bone, is of importance with reference to the operations of trephining the mastoid cells, opening the tympanum, and exposing the sinus itself, in septic thrombosis, etc. The course of the sinus corresponds to a line drawn from the external occipital protuberance to the base of the mastoid process, or to the asterion, and thence over the back of the mastoid process in a curved line towards its apex.

(8) The **superior petrosal sinus** (figs. 477, 478) runs at the attached margin of the tentorium cerebelli, along the upper border of the petrous portion of the temporal bone. It connects the cavernous with the transverse (lateral) sinus. Leaving the outer and back part of the cavernous sinus just below the fourth nerve, it crosses the fifth nerve, and, after grooving the petrous bone, ends in the transverse sinus as the latter turns downwards on the mastoid portion of the temporal bone. It receives veins from the temporal lobe of the cerebrum, veins from the cerebellum, veins from the tympanum through the squamo-petrosal fissure, and sometimes the anterior temporal veins of the diploë.

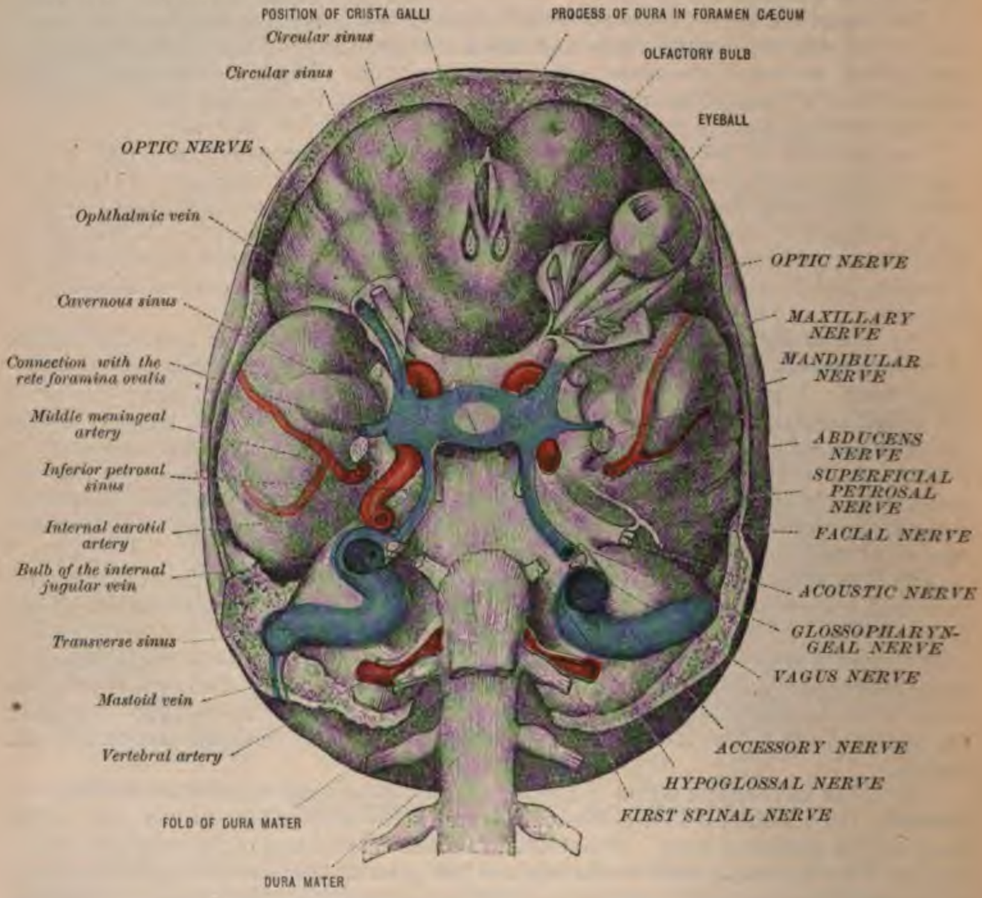
(9) The **inferior petrosal sinus** (figs. 477, 479) runs along the line of the petro-occipital suture, and connects the cavernous sinus with the commencement of the internal jugular vein. It is shorter than the superior petrosal, but considerably wider. As it crosses the anterior compartment of the jugular foramen, it separates the glosso-pharyngeal from the vagus and spinal accessory nerves. It receives veins from the inferior surface of the cerebellum, from the medulla and pons, and from the internal ear. The last issue through the aqueductus vestibuli and canaliculus cochleæ.

(10) The **cavernous sinus** (fig. 479) is an irregular shaped venous space situated between the meningeal and periosteal layers of the dura mater on the side of the body of the sphenoid bone. It extends from the central end of the superior orbital (sphenoidal) fissure in front to the apex of the petrous bone behind. Its outer wall is the more distinct, and contains in it, but separated from the blood by the lining membrane of the sinus, the third and fourth nerves, and the ophthalmic division of the fifth nerve, the nerves lying in the above-mentioned order from above downwards, and from within outwards. The internal carotid artery and the sixth nerve also pass through the sinus, being separated from the blood by the endothelial lining. The inner wall is practically absent, the blood-space communicating across the middle line with the opposite sinus in front, behind, and below the pituitary body or hypophysis cerebri. (See CIRCULAR SINUS.) The cavernous sinus is traversed by numerous trabeculæ or fibrous bands, so that there is no central space, but rather a number of endothelially-lined irregular lacunar cavities communicating with each other. Hence its name cavernous, from its resemblance to cavernous tissue. **In front** it receives the ophthalmic vein, with which it is practically continuous, and just above the third nerve the spheno-parietal sinus. **Internally** it communicates with the opposite sinus, and **posteriorly** it ends in the superior and inferior petrosal

sinuses. It also receives veins from the inferior surface of the frontal lobe of the brain, and some of the middle cerebral veins. Through the Vesalian vein, which runs in a minute foramen in the spinous process of the sphenoid bone, the sinus communicates with the pterygoid plexus of veins; through the venous plexus around the intraosseous portion of the internal carotid, with the internal jugular vein; and through a venous rete which leaves the cranium by the foramen ovale and by small veins passing through the foramen lacerum medium, with the pterygoid and pharyngeal plexuses.

(11) The **spheno-parietal sinus** runs in a slight groove on the under surface of the lesser wing of the sphenoid bone. It originates in one of the meningeal veins near the apex of the lesser wing, and, running inwards, passes through the sphenoidal fold of dura mater above the third nerve into the front part of the cavernous sinus. It generally receives the anterior temporal veins from the diploë.

FIG. 479.—THE VENOUS SINUSES AT THE BASE OF THE BRAIN. The dura mater has not been removed. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

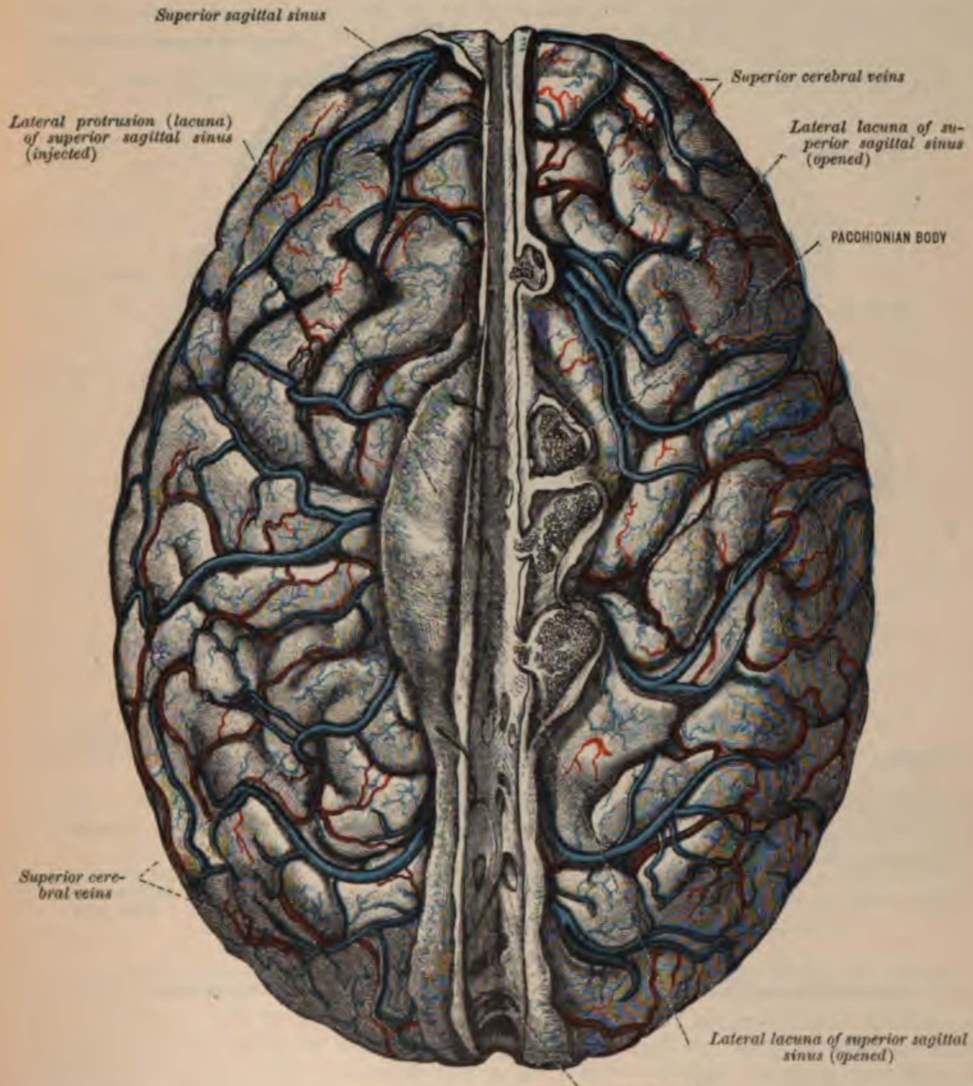

POSITION OF CRISTA GALLI
Circular sinus
PROCESS OF DURA IN FORAMEN CÆCUM
OLFACTORY BULB
Circular sinus
EYEBALL
OPTIC NERVE
Ophthalmic vein
OPTIC NERVE
Cavernous sinus
MAXILLARY NERVE
Connection with the rete foramina ovalis
MANDIBULAR NERVE
Middle meningeal artery
ABDUCENS NERVE
Inferior petrosal sinus
SUPERFICIAL PETROSAL NERVE
Internal carotid artery
FACIAL NERVE
Bulb of the internal jugular vein
ACOUSTIC NERVE
Transverse sinus
GLOSSOPHARYNGEAL NERVE
VAGUS NERVE
Mastoid vein
ACCESSORY NERVE
Vertebral artery
HYPOGLOSSAL NERVE
FIRST SPINAL NERVE
FOLD OF DURA MATER
DURA MATER

The **petro-squamous sinus** is occasionally present. It lies in a groove along the junction of the petrous and squamous portions of the temporal bone. It opens posteriorly into the transverse sinus at the spot where the latter enters on its sigmoid course. In front it sometimes, though very rarely, passes through a foramen in the squamous portion of the temporal bone between the glenoid cavity and the external auditory meatus into the temporal vein. This sinus is the rudiment of what in early fœtal life, before the development of the internal jugular vein, was the continuation of the lateral sinus, the blood from the interior of the skull at this period passing through the above-mentioned foramen into the primitive jugular vein.

3. THE VEINS OF THE BRAIN

The **veins of the brain** present the following peculiarities:—(*a*) They do not accompany the cerebral arteries. (*b*) Ascending veins do not, as in other situations, run with descending arteries, but with ascending arteries, and *vice versâ*. (*c*) The deep veins do not freely communicate. (*d*) The veins have very thin walls, no muscular coat, and no valves. (*e*) The veins opening into the sagittal, and some of those opening into the transverse (lateral) sinus pour in their blood in a direction opposite to the current in the sinuses, so impeding the flow in both vein and sinus. (*f*) The flow of blood in the sinuses is further retarded by the trabeculæ stretching across their lumen, and in the sagittal sinus by the blood having to ascend, when the body is erect, through the anterior half of its course.

FIG. 480.—THE VEINS OF THE BRAIN, SUPERIOR SURFACE. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Superior sagittal sinus
Superior cerebral veins
Lateral protrusion (lacuna) of superior sagittal sinus (injected)
Lateral lacuna of superior sagittal sinus (opened)
PACCHIONIAN BODY
Superior cerebral veins
Lateral lacuna of superior sagittal sinus (opened)
PACCHIONIAN BODY

The veins of the brain may be divided into the **cerebral** and the **cerebellar.**

THE CEREBRAL VEINS

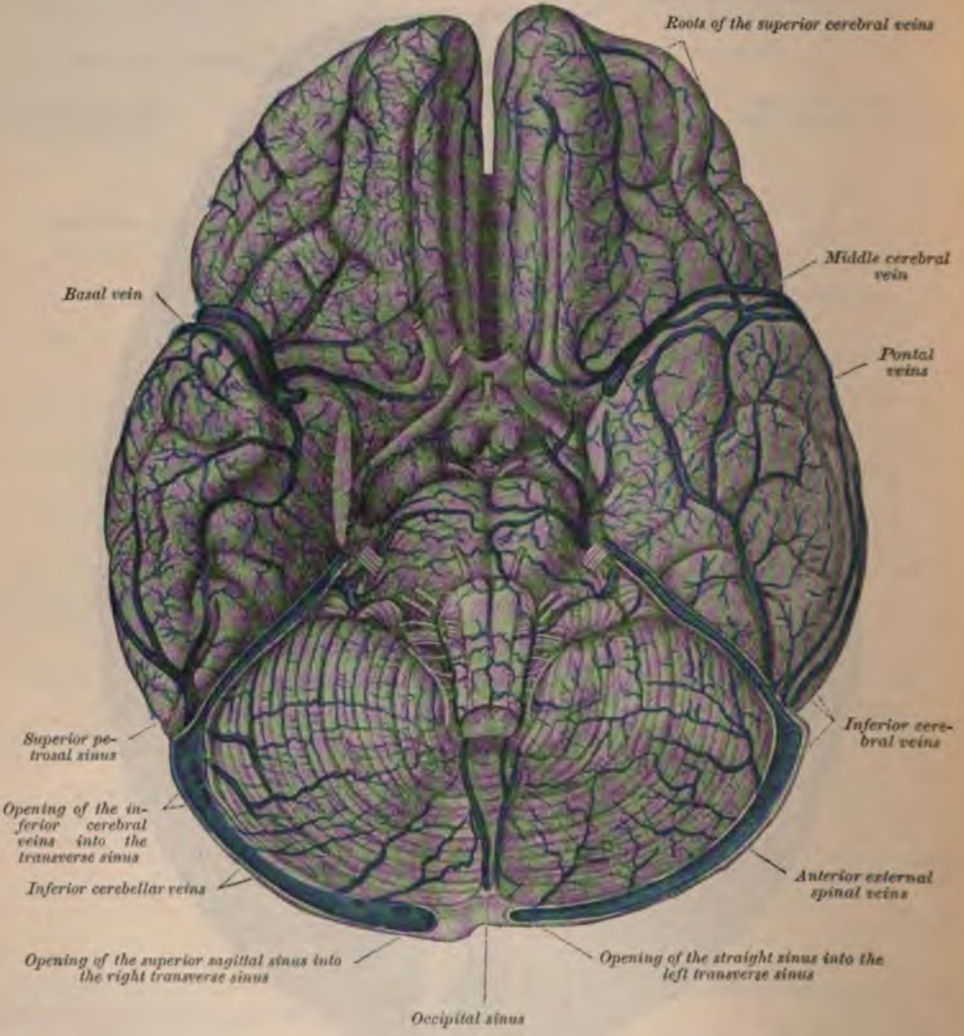
The **cerebral veins,** like the cerebral arteries, may be divided into the **cortical** and the **central** or **ganglionic.**

The **cortical** or **superficial veins** ramify on the surface of the brain and return the blood from the cortical substance into the venous sinuses. They lie for the most part in the sulci between the convolutions, but some pass over the convolutions from one sulcus to another. They consist of two sets: a superior and an inferior.

(1) The **superior cerebral veins,** some eight to twelve in number on each side, are formed by the union of branches from the convex and median surfaces of the cerebrum. Those from the convex surface pass forwards and inwards towards the longitudinal fissure, where they are joined by the branches coming from the median surface. After receiving a sheath from the arachnoid, they enter obliquely into the superior sagittal sinus, running for some distance in its walls. These veins freely communicate with each other, thus differing from the cortical arteries. They also communicate with the inferior cortical veins. They may be roughly divided into (*a*) frontal; (*b*) paracentral; (*c*) central; (*d*) occipital.

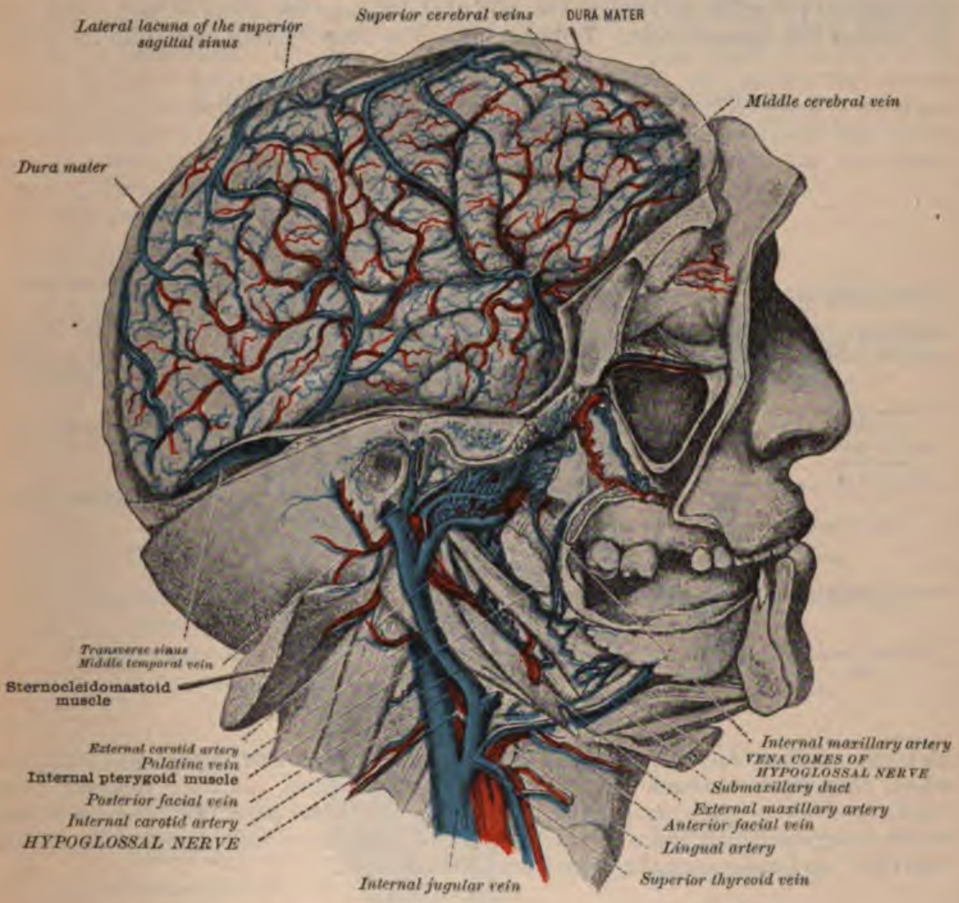
(2) The **inferior cerebral veins** ramify on the base of the hemisphere and the

FIG. 481.—THE VEINS OF THE BRAIN, INFERIOR SURFACE. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Roots of the superior cerebral veins
Middle cerebral vein
Basal vein
Pontal veins
Superior petrosal sinus
Inferior cerebral veins
Opening of the inferior cerebral veins into the transverse sinus
Inferior cerebellar veins
Anterior external spinal veins
Opening of the superior sagittal sinus into the right transverse sinus
Opening of the straight sinus into the left transverse sinus
Occipital sinus

lower part of its outer surface. Those on the inferior surface of the frontal lobe pass, in part into the inferior sagittal sinus, and in part into the cavernous sinus. Those on the temporal lobe enter in part into the superior petrosal sinus, and in part into the transverse (lateral) sinus, passing into the latter from before backwards. A large vein from the occipital lobe winds over the cerebral peduncle and joins the great vein of Galen just before the latter enters the straight sinus. One of the inferior cortical veins is called the **middle cerebral vein;** it runs in the fissure of Sylvius and ends in the cavernous sinus. Another, the great anastomosing vein of Trolard, a branch of the middle cerebral, establishes a communication between the superior sagittal and cavernous sinuses by anastomosing with one of the superior cortical veins. A second anastomotic vein, that of Labbé, is also a branch of the middle cerebral, and connects the veins over the temporal lobe with the transverse sinus.

FIG. 482.—THE VEINS OF THE BRAIN, LATERAL SURFACE. (After Toldt, "Atlas of Human Anatomy," London and New York.)


Lateral lacuna of the superior sagittal sinus
Superior cerebral veins
DURA MATER
Middle cerebral vein
Dura mater
Transverse sinus
Middle temporal vein
Sternocleidomastoid muscle
External carotid artery
Palatine vein
Internal pterygoid muscle
Posterior facial vein
Internal carotid artery
HYPOGLOSSAL NERVE
Internal jugular vein
Internal maxillary artery
VENA COMES OF HYPOGLOSSAL NERVE
Submaxillary duct
External maxillary artery
Anterior facial vein
Lingual artery
Superior thyreoid vein

The **central, ganglionic,** or **deep cerebral veins** are collected into two large venous trunks, the venæ Galeni, which leave the brain at the transverse fissure, that is, between the splenium of the corpus callosum and the corpora quadrigemina. At this spot they unite to form the great vein of Galen, which opens into the anterior end of the straight sinus. The veins of Galen are formed by the union of the chorioid vein with the vein of the corpus striatum near the foramen of Monro. From this spot they run backwards parallel to each other, between the layers of the tela chorioidea, and terminate in the way above mentioned.

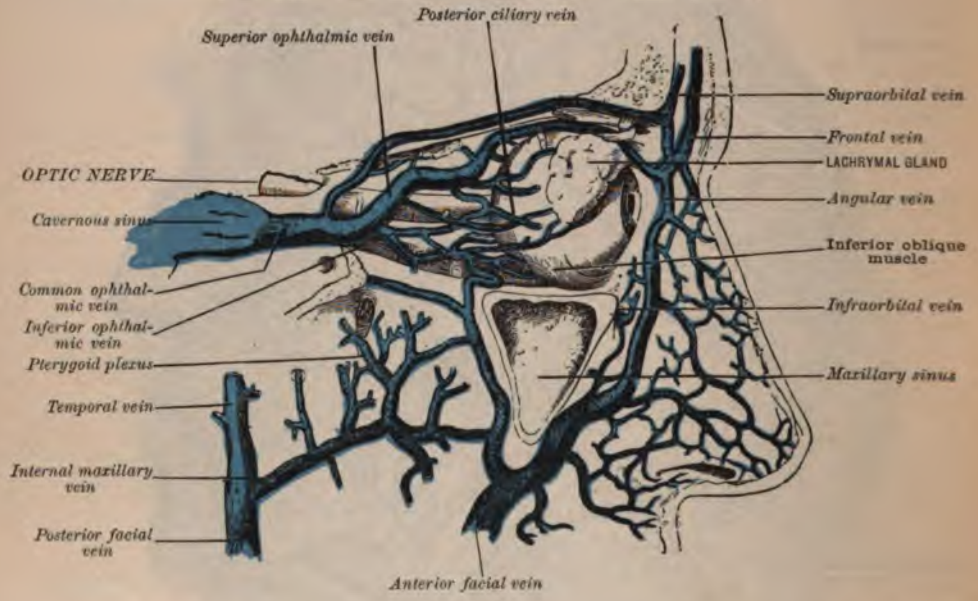
Tributaries of the veins of Galen.—The chorioid vein, the vein of the corpus striatum, the basal vein, the veins of the thalamus, the vein of the chorioid plexus of the third ventricle, and veins from the corpus callosum, the pineal body, the corpora quadrigemina, and posterior horn of the lateral ventricle. The united trunk, or great vein of Galen, receives veins from the upper surface of the cerebellum, and one of the posterior inferior cerebral veins.

The **chorioid vein** runs with the chorioid plexus. It begins in the inferior cornu of the lateral ventricle, and ascends on the outer side of the chorioid plexus along the margin of the tela chorioidea to the foramen of Monro, where it unites with the vein of the corpus striatum to form the vein of Galen. It receives tributaries from the hippocampus, corpus callosum, and fornix.

The **vein of the corpus striatum,** formed by veins from the corpus striatum and thalamus, runs forwards in the groove between those structures, passing in its course beneath the stria terminalis, and joins the vein of Galen at the foramen of Monro. **Tributaries.**—It receives, in addition to the veins from the corpus striatum and thalamus, small veins from the fornix, septum pellucidum, and anterior cornu of the lateral ventricle.

The **basal vein,** formed by the confluence of the deep Sylvian vein, the inferior striate veins, and some small anterior cerebral veins, runs backwards over the cerebral peduncle, and enters the vein of Galen near the union of that vessel with the vein of the opposite side. **Tributaries.**—The deep Sylvian vein from the insula and surrounding convolutions; the inferior striate veins from the corpus striatum, which they leave through the anterior perforated space; anterior cerebral veins from the front of the corpus callosum; interpeduncular veins from the structures in the interpeduncular space; ventricular veins from the middle cornu of the lateral ventricle; and mesencephalic veins from the mid-brain.

FIG. 483.—THE OPHTHALMIC VEINS. (After Quain.)


Posterior ciliary vein
Superior ophthalmic vein
Supraorbital vein
Frontal vein
LACHRYMAL GLAND
OPTIC NERVE
Angular vein
Cavernous sinus
Inferior oblique muscle
Common ophthalmic vein
Infraorbital vein
Inferior ophthalmic vein
Pterygoid plexus
Maxillary sinus
Temporal vein
Internal maxillary vein
Posterior facial vein
Anterior facial vein

The Cerebellar Veins

The **cerebellar veins** are divided into the **superior** and **inferior.**

The **superior** ramify on the upper surface of the cerebellum; some of them run inwards over the superior vermis to join the straight sinus and great vein of Galen; others run outwards to the transverse (lateral) and superior petrosal sinuses.

The **inferior,** larger than the superior, run, some forwards and outwards to the inferior petrosal and transverse (lateral) sinuses, and others directly backwards to the occipital sinuses.

The Veins of the Medulla and Pons

The veins from the **medulla oblongata** and the **pons** terminate in the inferior petrosal and transverse (lateral) sinuses.

4. THE VEINS OF THE NASAL CAVITIES

The venous plexuses on the inferior nasal concha (turbinate bone) and back of the septum are described with the NOSE. The veins leaving the nasal cavities follow roughly the course of their corresponding arteries. Thus the spheno-palatine veins pass through the spheno-palatine foramen into the pterygoid plexus; the anterior and posterior ethmoidal veins join the ophthalmic. Small veins accompany branches of the external maxillary (facial) artery through the nasal bones and nasal processes of the maxillary bones, and end in the angular and anterior facial veins; and other small veins pass from the nose anteriorly into the superior labial, and thence to the anterior facial.

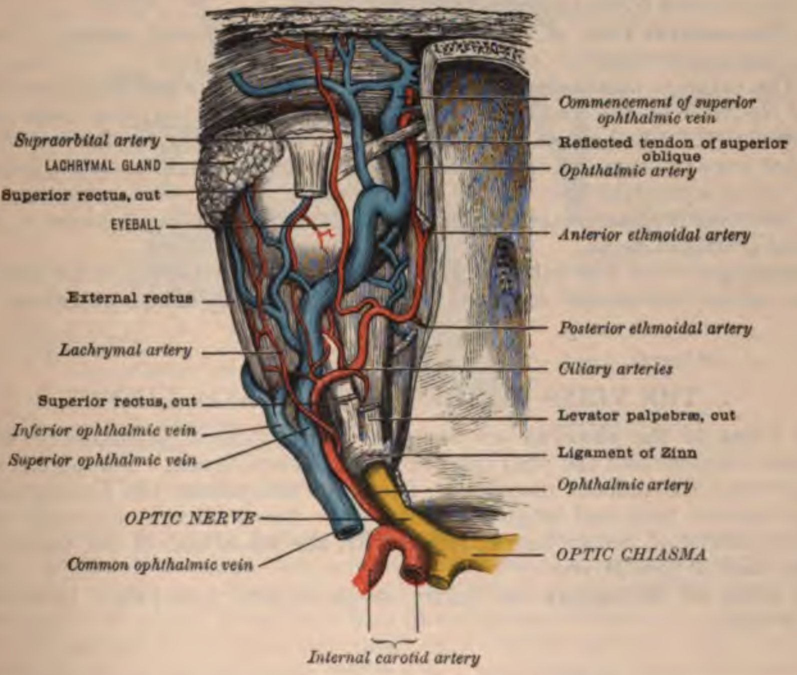
5. THE VEINS OF THE EAR

The veins from the external ear and external auditory meatus join the temporal and posterior auricular veins. The veins from the tympanum open into the superior petrosal sinus and posterior facial (temporo-maxillary) vein. The blood from the labyrinth flows chiefly through the internal auditory veins which lie with the internal auditory artery in the internal auditory meatus, and enters the inferior petrosal or transverse sinus. Some of the blood from the labyrinth, however, passes through the vestibular vein which lies in the aquæductus vestibuli, into the inferior petrosal sinus, and some through the canaliculus cochleæ into the commencement of the internal jugular vein.

6. THE VEINS OF THE ORBIT

The blood from the eyeball and orbit is returned by the ophthalmic vein into the cavernous sinus. This vein and its tributaries have no valves, and communicate in front with the frontal, supraorbital, and other veins. Hence under certain conditions, as from pressure on the cavernous sinus, the blood may flow in the contrary direction to the normal—i. e., from behind forwards into the frontal and supraorbital, and thence through the angular vein into the anterior facial. In this

FIG. 484.—THE VEINS OF THE ORBIT.


Supraorbital artery
LACHRYMAL GLAND
Superior rectus, cut
EYEBALL
External rectus
Lachrymal artery
Superior rectus, cut
Inferior ophthalmic vein
Superior ophthalmic vein
OPTIC NERVE
Common ophthalmic vein
Commencement of superior ophthalmic vein
Reflected tendon of superior oblique
Ophthalmic artery
Anterior ethmoidal artery
Posterior ethmoidal artery
Ciliary arteries
Levator palpebræ, cut
Ligament of Zinn
Ophthalmic artery
OPTIC CHIASMA
Internal carotid artery

way pressure on the retinal veins is quickly relieved, and little or no distension occurs in cases of obstruction in the cavernous sinus.

The **ophthalmic vein,** or **common ophthalmic vein,** is formed by the confluence at the back of the orbit of the superior and inferior ophthalmic veins. It is a short thick trunk, and passes backwards between the two heads of the external rectus muscle below the sixth nerve, and at the inner part of the superior orbital (sphenoidal) fissure leaves the orbit and enters the front part of the cavernous sinus.

A. The **superior ophthalmic vein,** larger than the inferior, begins at the inner canthus of the eyelid by a free communication with the frontal, supraorbital, and angular veins, and thence runs backwards and outwards with the ophthalmic artery across the optic nerve to the inner end of the superior orbital (sphenoidal) fissure, where it joins the inferior ophthalmic vein to form the common ophthalmic trunk. In this course it lies anterior and superficial to the ophthalmic artery.

Tributaries.—(1) The superior muscular veins; (2) the veins of the lids and conjunctiva; (3) the ciliary veins; (4) the anterior and posterior ethmoidal veins; (5) the lachrymal vein; and (6) the central vein of the retina.

(1) The **superior muscular branches** are derived from the levator palpebræ, superior rectus, superior oblique, and internal rectus.

(2) The **palpebral** and **conjunctival,** both anterior and posterior, open into the superior ophthalmic.

(3) The **ciliary veins,** the veins of the eyeball, are divided into two sets:—an **anterior,** which emerge from the eyeball with the anterior ciliary arteries, and open into the muscular veins returning the blood from the four recti; and a **posterior set,** known as the **venæ vorticosæ,** which leave the globe midway between the cornea and the entrance of the optic nerve. The latter veins are four or five in number, the upper ending in the superior, the lower in the inferior ophthalmic vein (fig. 483).

(4) The **anterior and posterior ethmoidal veins** correspond in their course with the arteries of the same name. They enter the orbit through the anterior and posterior ethmoidal foramina, and join either the ophthalmic direct, or one or other of the superior muscular branches.

(5) The **lachrymal vein** returns the blood from the lachrymal gland, and corresponds in its course to the lachrymal artery.

(6) The **central vein of the retina** runs with the central artery in the optic nerve. It joins the superior ophthalmic at the back of the orbit.

B. The **inferior ophthalmic vein,** smaller than the superior, is formed near the front of the orbit by the confluence of the inferior muscular with the lower posterior ciliary veins. It runs backwards below the optic nerve, along the floor of the orbit, and either joins the superior ophthalmic vein to form the common ophthalmic trunk, or else opens separately into the cavernous sinus. A large communicating branch passes downwards through the inferior orbital (spheno-maxillary) fissure to join the pterygoid plexus of veins.

Tributaries.—(1) The **inferior muscular,** which are derived from the inferior oblique, inferior rectus, and external rectus; and (2) the **lower posterior ciliary veins.**

7. THE VEINS OF THE PHARYNX AND LARYNX

The **veins of the pharynx** are arranged in the form of a plexus, between the constrictor muscles and the pharyngeal or prevertebral fascia. The plexus receives branches from the mucous membrane, from the soft palate, the Eustachian tube, and the anterior recti and longus colli muscles. Above, it communicates with the pterygoid plexus of veins; below, either with the lower end of the facial vein or with the internal jugular vein.

The **veins of the larynx** end partly in the superior and partly in the inferior thyreoid veins.

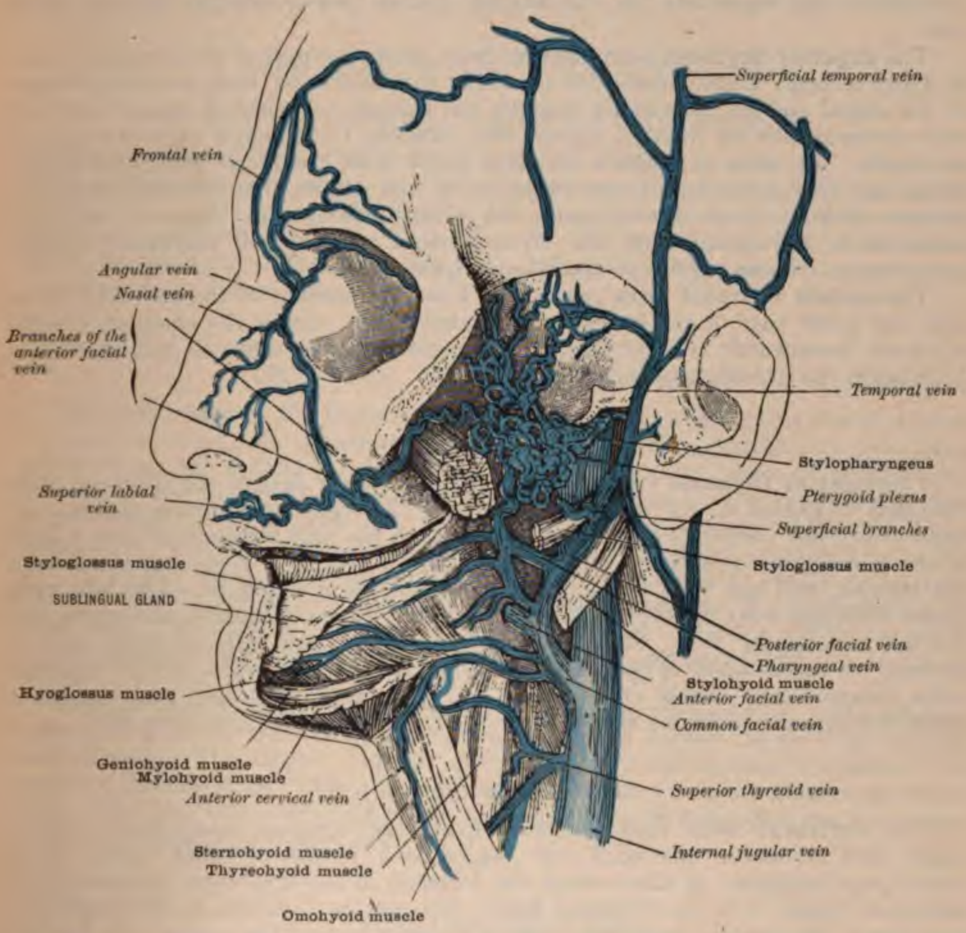
8. THE DEEP VEINS OF THE NECK

The **deep veins of the neck** are the internal jugular vein, the vertebral vein, and the deep cervical vein, and their respective tributaries.

The Internal Jugular Vein

The **internal jugular vein** begins at the jugular fossa, and is the continuation of the transverse sinus. It passes down the neck, in company first with the internal carotid artery and then with the common carotid artery, to a spot a little external to the sterno-clavicular articulation, where it joins the subclavian to form the innominate vein. At its commencement in the larger, posterior and external part of the jugular foramen, it is somewhat dilated, forming the so-called **bulb** or **sinus** of the internal jugular vein (fig. 485). This dilated part of the internal jugular vein lies in the jugular fossa of the temporal bone and is therefore in immediate relation to the floor of the tympanum. At first the internal jugular lies in front of the rectus capitis lateralis, and behind the internal carotid artery, from which it is separated by the hypoglossal, glosso-pharyngeal, and vagus nerves, and by the carotid plexus of the sympathetic. But as it descends it passes gradually to the outer side of that vessel, and retains this relation as far as the upper border of the thyreoid cartilage. Thence it runs to its termination along the outer side of the common carotid artery, being contained in the same sheath with it and the vagus nerve, but separated from these structures by a distinct septum. The vein generally overlaps the artery in front; hence the importance in tying the carotid of opening the sheath well to the inner side of that vessel, in order to avoid the vein. About 2·5 cm. (1 in.) above its termination it contains a pair of imperfect valves.

Fig. 485.—The Internal Jugular Vein. (After Henle.)


Superficial temporal vein
Frontal vein
Angular vein
Nasal vein
Branches of the anterior facial vein
Temporal vein
Stylopharyngeus
Pterygoid plexus
Superior labial vein
Superficial branches
Styloglossus muscle
Styloglossus muscle
SUBLINGUAL GLAND
Posterior facial vein
Pharyngeal vein
Stylohyoid muscle
Anterior facial vein
Hyoglossus muscle
Common facial vein
Geniohyoid muscle
Mylohyoid muscle
Anterior cervical vein
Superior thyreoid vein
Sternohyoid muscle
Thyreohyoid muscle
Internal jugular vein
Omohyoid muscle

Tributaries.—At the bulb or sinus the internal jugular vein receives the inferior petrosal sinus; the vein of the cochlear canaliculus, and a meningeal vein;

opposite the angle of the jaw veins from the pharyngeal plexus, and often a communicating branch from the external jugular vein; opposite the bifurcation of the carotid it is joined by the common facial, and a little lower down by the lingual and the superior thyreoid vein, and at the level of the cricoid cartilage by the middle thyreoid vein.

The inferior petrosal sinus is described with the other sinuses of the brain (p. 655); the pharyngeal plexus with the veins of the pharynx (see p. 662); and the common facial vein with the superficial veins of the scalp and face (p. 646).

The **lingual vein** begins near the tip of the tongue, under the name of the **ranine.** It lies at first close to the hypoglossal nerve and beneath the mucous membrane covering the under surface of the tongue. It then passes backwards across the hyo-glossus, which intervenes between it and the lingual artery. After receiving the sublingual vein and the dorsal lingual veins which roughly correspond to their respective arteries, and the two small veins (venæ comites) which frequently accompany the lingual artery beneath the hyo-glossus, the united trunk crosses the common carotid artery and opens into the internal jugular vein. At times these tributaries open separately into the internal jugular vein or into the common facial vein.

The **superior thyreoid vein** emerges from the upper part of the thyreoid body, in which it freely anastomoses with the other thyreoid veins, both in the substance of the organ and on its surface beneath the capsule. Thence it passes upwards and outwards into the internal jugular vein, crossing the common carotid artery in its course. At times it forms a common trunk with the facial vein. Its **tributaries** are the sterno-hyoid, sterno-thyreoid, and thyreo-hyoid veins from the muscles bearing those names; and the crico-thyreoid and superior laryngeal veins which correspond with the crico-thyreoid and superior laryngeal arteries respectively. These require no special description.

The **middle thyreoid vein** passes out from the capsule of the thyreoid gland near the lower part of the lateral lobe of that body, crosses the common carotid obliquely downwards and outwards, and opens into the internal jugular vein a little below the cricoid cartilage.

THE INFERIOR THYREOID VEINS

The **inferior thyreoid veins** descend from the lower part of the thyreoid body obliquely outwards to the innominate veins. The **right vein** crosses the innominate artery just before its bifurcation, and ends in the right innominate vein a little above the superior vena cava. It receives inferior laryngeal veins and veins from the trachea, and has valves at its termination in the innominate. The **left vein** passes obliquely over the trachea behind the sterno-thyreoid muscle, and opens into the left innominate vein. It also receives laryngeal and tracheal veins, and is guarded by valves where it opens into the innominate trunk. The inferior thyreoid veins communicate across the trachea by transverse branches, and they not unfrequently unite to form a single trunk which joins the left innominate vein.

THE VERTEBRAL VEINS

The **vertebral vein** does not accompany the vertebral artery in its fourth stage, that is, within the skull, but begins as a plexus of small veins in the suboccipital triangle. It then enters the foramen in the transverse process of the altas, and passes with the vertebral artery through the foramina in the transverse processes of the cervical vertebræ, forming a plexus around the artery. On leaving the transverse process of the sixth cervical vertebra it crosses in front of the subclavian artery and opens into the innominate vein. It has one or two semilunar valves at its entrance into the innominate vein. In the suboccipital triangle it communicates with the intraspinal, deep cervical, and occipital veins, and is joined by veins from the recti and oblique muscles and the pericranium.

Tributaries.—As it passes down the neck it receives (1) lateral spinal veins, which issue along with the cervical nerves and lateral spinal arteries from the spinal canal; (2) branches from the venous plexus about the bodies of the cervical vertebræ and their transverse processes; (3) branches from the deep cervical muscles; and (4) branches from the cervical dorsal spinal veins. Just before it terminates in the innominate it is joined by (5) the deep cervical vein (sometimes); (6) the anterior vertebral vein; and (7) the upper superior intercostal vein (sometimes).

The **anterior vertebral vein** begins in a plexus in front of the bodies of the cervical vertebræ, and, running downwards with the ascending cervical artery between the scalenus anterior and longus colli muscles, opens into the vertebral vein just before the latter ends in the innominate. It receives tributaries from the scaleni, longus colli and capitis, and rectus capitis anterior muscles.

The **deep cervical vein** begins as a plexus of small vessels in the suboccipital triangle. It sometimes receives the occipital vein, and passes downwards between the semispinalis capitis (complexus) and colli to join either the vertebral or the innominate vein.

THE VEINS OF THE THORAX

THE SUPERFICIAL VEINS OF THE THORAX

The **superficial veins** of the front of the thorax can be seen in fig. 471. They form a plexus over the entire chest in which the largest vessels are the lateral thoracic veins, which drain to the axilla. The plexus has numerous connections with the internal mammary, intercostal, and cervical veins. A similar complete plexus of veins is found on the back of the chest, which drains through the numerous perforating branches of the intercostals.

THE DEEP VEINS OF THE THORAX

The **deep veins of the thorax** are:—the pulmonary, which carry the blood from the lung to the left side of the heart; and the superior vena cava and its tributaries, which return the venous blood from the head and neck, the upper extremities, and the walls of the thorax, to the right side of the heart; the azygos veins, which open into the superior vena cava and return blood from the intercostal, bronchial, and œsophageal veins, the internal mammary veins, the mediastinal, pericardiac, and thymic veins, and the spinal veins, in part. The inferior vena cava, which brings back the blood from the abdomen and pelvis and lower extremities, is described with the veins of the abdomen, in which cavity it lies throughout by far the greater part of its course, somewhat less than 1·2 cm. ($\frac{1}{2}$ in.) of its upper end only being situated in the thorax.

The pulmonary veins are contained in the middle mediastinum. The superior vena cava and the right and left innominate veins course through the superior mediastinum. The azygos veins lie on either side of the thoracic vertebræ in the posterior mediastinum. The internal mammary veins lie in the anterior mediastinum. Of these veins, the pulmonary, the superior vena cava, and the innominate veins have already been described.

THE AZYGOS VEINS

The **azygos veins** are longitudinal veins, the remnants of the posterior cardinals, which are the main collecting trunks for the posterior part of the body in the embryo. They lie along the sides of the thoracic vertebræ, and collect the blood from the intercostal veins; they are the upward continuation of longitudinal anastomotic trunks which drain the lumbar veins. The azygos veins are three in number, the azygos (azygos major) on the right side, and the hemiazygos (azygos minor) and accessory hemiazygos (azygos tertia) on the left.

The **azygos vein** (azygos major) begins in the abdomen as a continuation upwards of the ascending lumbar vein. Through this means it connects with the iliac veins and it has also an anastomosis with the inferior vena cava which may become very important in cases of obstruction of the vena cava. It passes through the aortic opening of the diaphragm, runs up through the posterior mediastinum on the right side of the front of the bodies of the thoracic vertebræ as high as the fourth thoracic vertebra, in this part of its course lying to the right of the aorta and thoracic duct; it then curves forwards over the root of the right lung, and opens into the superior vena cava immediately before the latter pierces the pericardium.

It usually contains an imperfect pair of valves at the spot where it turns forwards from the fourth thoracic vertebra to arch over the root of the lung; and still more imperfect valves are found at varying intervals lower down the vein.

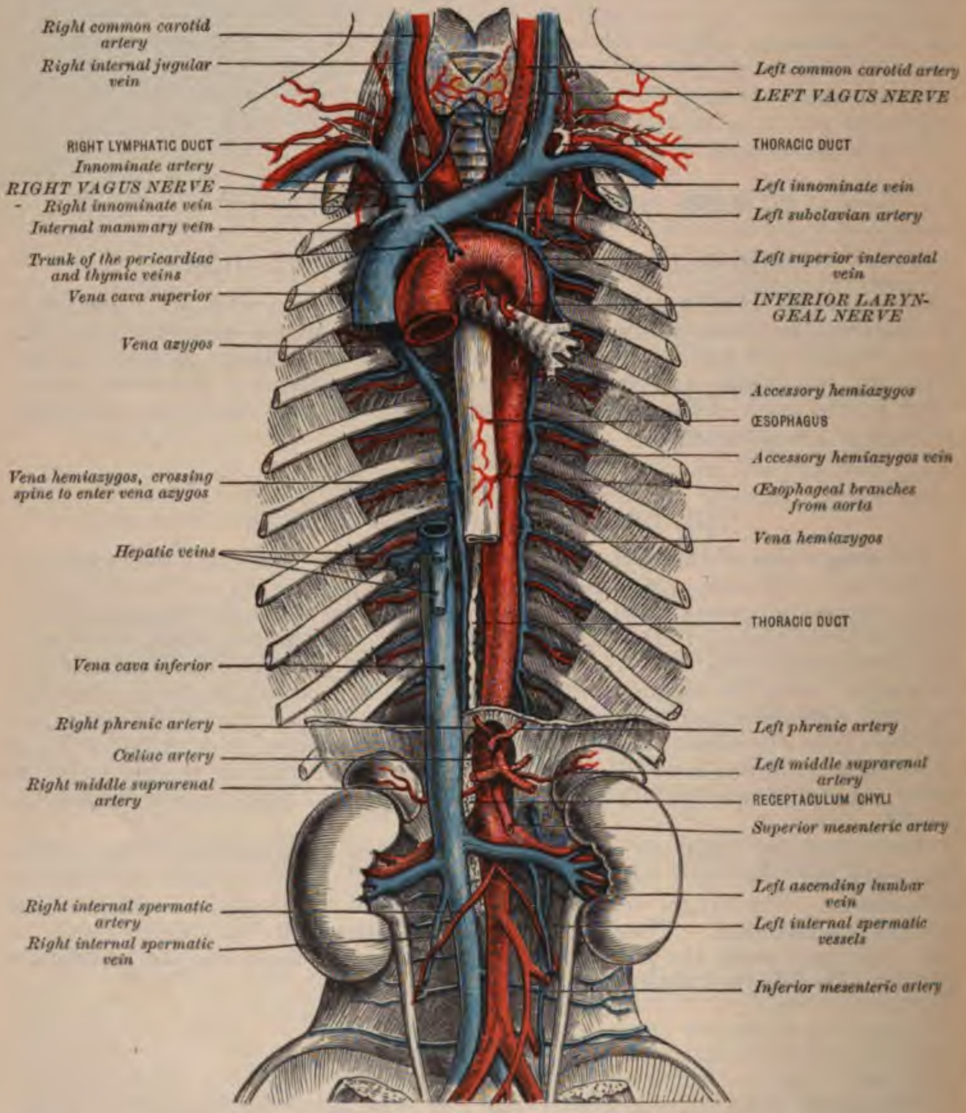


Fig. 486.—The Superior and Inferior Venæ Cavæ, the Innominate Veins, and the Azygos Veins.

Right common carotid artery
Right internal jugular vein
RIGHT LYMPHATIC DUCT
Innominate artery
RIGHT VAGUS NERVE
Right innominate vein
Internal mammary vein
Trunk of the pericardiac and thymic veins
Vena cava superior
Vena azygos
Vena hemiazygos, crossing spine to enter vena azygos
Hepatic veins
Vena cava inferior
Right phrenic artery
Cœliac artery
Right middle suprarenal artery
Right internal spermatic artery
Right internal spermatic vein
Left common carotid artery
LEFT VAGUS NERVE
THORACIC DUCT
Left innominate vein
Left subclavian artery
Left superior intercostal vein
INFERIOR LARYNGEAL NERVE
Accessory hemiazygos
ŒSOPHAGUS
Accessory hemiazygos vein
Œsophageal branches from aorta
Vena hemiazygos
THORACIC DUCT
Left phrenic artery
Left middle suprarenal artery
RECEPTACULUM CHYLI
Superior mesenteric artery
Left ascending lumbar vein
Left internal spermatic vessels
Inferior mesenteric artery

It receives the intercostal veins of the right side, except the first; the next two or three veins are first collected into a common trunk before joining the azygos vein. It also receives the two azygos veins of the left side, the right bronchial vein, and small œsophageal, pericardiac, and posterior mediastinal veins.

The **hemiazygos vein** (azygos minor) begins in the abdomen by communicating, like the azygos vein, with the ascending lumbar vein of the left side. Through this vein it communicates with the lumbar veins, the renal, and the iliac veins, and according as one or other portion of the ascending lumbar is enlarged and other portions are diminished in size or obliterated, so may the hemiazygos vein appear to begin in the inferior vena cava or in a lumbar, the renal, or one of the iliac veins. The hemiazygos vein, after receiving the left lowest intercostal vein, passes through the left crus of the diaphragm, and courses up the posterior mediastinum to the left of the bodies of the lower thoracic vertebræ as high as the eighth, where it turns obliquely to the right, and, crossing in front of the spinal column behind the aorta and the œsophagus, opens into the vena azygos. In its course it crosses over three or four of the lower left intercostal arteries, and is covered by the pleura.

Tributaries.—(1) The lower five left intercostal veins; (2) the lower end of the accessory hemiazygos vein (sometimes); (3) small left mediastinal veins; and (4) the lower left œsophageal veins.

The **accessory hemiazygos** (azygos tertia) varies considerably in size, position, and arrangement, and is often absent. It lies in the posterior mediastinum by the left side of the bodies of the fifth, sixth, and seventh thoracic vertebræ, and is more or less vertical in direction. It is continued above into the lower left superior intercostal vein, and below either joins the hemiazygos or passes obliquely across the sixth or seventh thoracic vertebra to join the azygos vein. The intercostal veins intervening between it and the hemiazygos then open directly across the spine into the azygos. It crosses the corresponding left intercostal arteries, and is covered by the pleura.

Tributaries.—(1) The fifth, sixth, and sometimes the seventh intercostal veins; (2) the lower end of the lower left superior intercostal vein; (3) the upper end of the hemiazygos minor (sometimes); and (4) the left bronchial vein.

Development of the azygos veins.—The azygos veins are the remains of the embryonic cardinal veins, which return the blood from the body walls and lower limb. They are two in number, one on either side, and extend throughout the entire length of the abdomen and thorax, uniting above with the embryonic jugular veins to form the ductus Cuvieri. When the inferior vena cava developes (p. 680), the abdominal portions of the cardinal veins degenerate, the lumbar and iliac veins transferring their connections to the vena cava, and the thoracic portion of the right cardinal becomes the vena azygos. When the lower part of the left jugular disappears (p. 643), the thoracic portion of the left cardinal makes connections across the middle line with the azygos and becomes converted into the hemiazygos and accessory hemiazygos veins, the connection which sometimes exists between the accessory hemiazygos and the oblique vein of the left atrium representing the original upper connection of the left cardinal. The development of the ascending lumbar veins and their connections with the azygos and hemiazygos veins are secondary events.

The intercostal veins.—The intercostal veins are twelve in number on each side, the last one being subcostal. They correspond with the intercostal arteries. There is one vein to each artery, the vein lying above the artery whilst in the intercostal space. Each vein has an intercostal and a dorsal branch. The dorsal tributary runs with the corresponding branch of the intercostal artery between the transverse process of the vertebræ and the neck of the rib. These dorsal branches not only return the blood from the muscles of the back, but have an important spinal branch from the dorsal spinal plexus and from the spinal veins through the intervertebral foramina. The relations of the spinal veins are described separately (p. 668). The intercostal veins also receive small tributaries from the bodies of the vertebræ. The termination of the intercostal veins is different on the two sides, and is seldom alike in any two consecutive subjects.

On the right side.—The first intercostal vein ascends with the superior intercostal artery, a branch of the subclavian, to end either in the vertebral vein just before the latter joins the right innominate vein, or in the right innominate direct. The second intercostal vein either joins with the first, and opens with it as a common trunk into the vertebral or innominate vein, or it joins with the third or with the third and fourth to open into the azygos vein as the latter is arching over the root of the right lung. The rest join the azygos directly. The upper of these have well-marked valves where they join the azygos vein; in the lower veins these valves are imperfect. All the intercostal veins are provided with valves in their course between the muscles.

On the **left side** the first intercostal vein also follows the superior intercostal artery from the subclavian, and ascends to join the left vertebral or left innominate vein; it is known as the **left superior intercostal vein.** The second intercostal vein either joins the first, and opens with it as a common trunk into the left vertebral or left innominate vein, or joins the third and fourth to form a single trunk, which passes upwards across the arch of the aorta and opens into the left innominate vein. This vein usually communicates at its lower end with the accessory hemiazygos vein, but at times it crosses the spine and enters directly the azygos vein. A fibrous cord can frequently be traced from it through the vestigial fold of the pericardium to the oblique vein of the left atrium (p. 479).

The **bronchial veins** correspond to the bronchial arteries, but do not return the whole of the blood carried to the lungs by those vessels—that part which is distributed to the smaller bronchial tubes and the alveolæ being brought back by the pulmonary veins. The bronchial veins issue from the lung substance behind the structures forming the root of the lung. The right vein generally joins the vena azygos just before the latter vein enters the superior vena cava. The left vein opens into the lower left superior intercostal vein, or into the accessory hemiazygos vein. The bronchial veins at the root of the lung receive small tributaries from the bronchial glands, from the trachea, and from the posterior mediastinum.

The **œsophageal veins** from the thoracic portion of the œsophagus end in part in the vena azygos, and in part in the vena hemiazygos.

THE INTERNAL MAMMARY VEINS

The internal mammary veins are formed by the union of the venæ comites of the branches of the internal mammary artery. Behind the first intercostal space the venæ comites unite to form a single trunk which opens into the innominate vein on the inner side of the internal mammary artery.

THE MEDIASTINAL, PERICARDIAC, AND THYMIC VEINS

The **mediastinal, pericardiac,** and **thymic veins** are small vessels, corresponding to the arteries of those names given off by the internal mammary. They do not, as a rule, join the internal mammary vein, but unite into a single trunk which passes over the transverse part of the arch of the aorta and opens into the lower and anterior part of the left innominate.

THE SPINAL VEINS

The **spinal veins,** which form plexuses around and within the spinal canal from the cranium to the sacrum, may be divided into the extra- and intraspinal veins. The **extraspinal** form a plexus both in front of the bodies of the vertebræ (the **anterior spinal plexus**), and in the spinal groove between the transverse and spinous processes—the **posterior spinal plexus,** as it is often called. The **intraspinal veins,** or those within the spinal canal, may be divided into the meningeal and the medullary. The **meningeal** form an anterior and a posterior spinal plexus between the dura mater and the walls of the spinal canal. They receive the veins from the bodies of the vertebræ. The **medullary set** are situated within the dura mater; they return the blood from the spinal cord, and are known as the **medulli-spinal veins.** All the plexuses drain into the vertebral vein in the neck and to the dorsal spinal branches of the intercostal, lumbar and sacral veins of the trunk.

1. **The extraspinal veins.**—(*a*) The veins of the **anterior spinal plexus** ramify in front of the bodies of the vertebræ (fig. 487). They are of small size and most distinct in the cervical region. They open into the neighbouring veins.

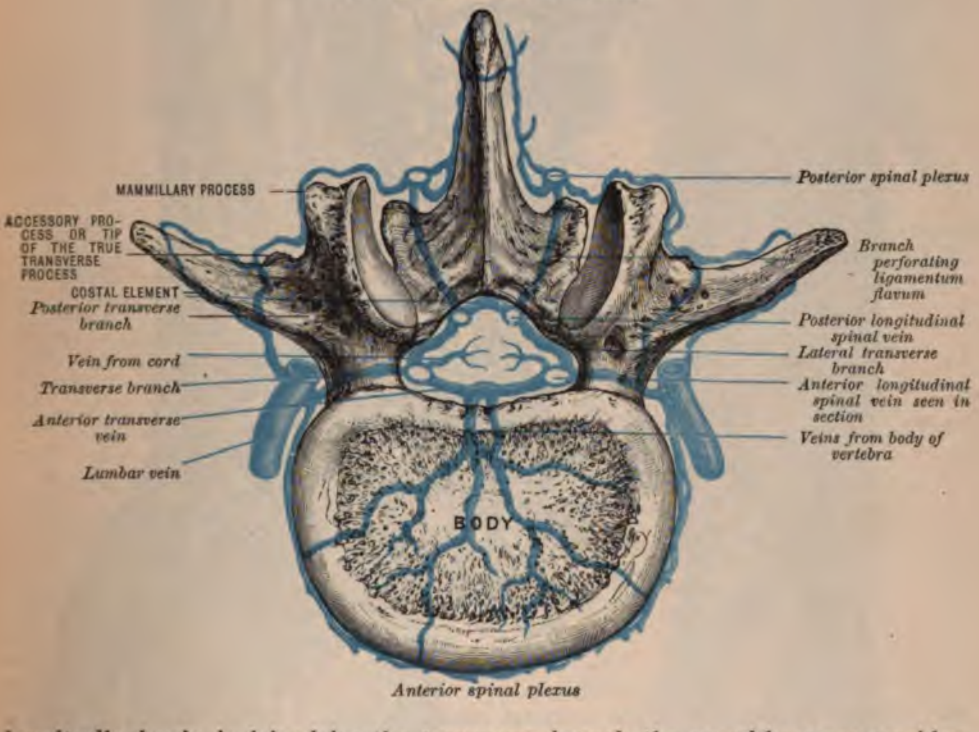
(*b*) The veins of the **posterior** or **dorsal spinal plexus** are situated around the spinous processes, the laminæ, and the articular and transverse processes of the vertebræ, the larger veins of the plexus running horizontally forwards along the interspinous ligaments. The plexus is formed chiefly by the union of tributaries proceeding from the integument of the back and the spinal muscles. Communications take place between the veins of each vertebral segment by vertical branches running upwards and downwards to the plexus above and below respectively, near the base of the transverse processes. Branches are also sent through the ligamenta flava between the laminæ of the several vertebræ to the posterior plexus of the intraspinal veins, and also forwards between the transverse processes of the vertebræ to join the vertebral vein in the neck, the dorsal branch of the intercostal veins in the thorax, the lumbar veins in the lumbar region, and the lateral sacral veins in the sacral region.

2. The **intraspinal veins** are divided into (*a*) the **meningeal;** and (*b*) the **medullary,** or **medulli-spinal.**

(*a*) The **meningeal veins** lie in the fatty tissue between the walls of the vertebral canal and the dura mater or theca vertebralis. They are arranged in four longitudinal channels, two of which are anterior and two posterior, united by transverse branches corresponding in number to the vertebral segments (fig. 488).

The **anterior longitudinal spinal veins** extend from the foramen magnum to the coccyx as two tortuous plexiform vessels, one being placed on each side of the back of the bodies of the vertebræ behind the posterior longitudinal ligament. Opposite the body of each vertebra they communicate by a transverse branch, which passes between the body of the vertebra and the posterior longitudinal ligament, an arrangement which is sometimes spoken of as the spinal venous ladder. Each transverse branch as it lies under cover of the posterior longitudinal ligament receives the veins from the bodies of the vertebræ (the **basivertebral veins**). At the spot where each longitudinal vein is joined by the transverse branch the vessel becomes considerably dilated. From the longitudinal vein branches run backwards to join the posterior longitudinal veins, and opposite the intervertebral foramina a transverse branch runs outwards to join the vertebral vein, the intercostal veins, the lumbar veins, or the sacral veins, according to the region of the spine in which the vertebra is situated. Above, the anterior spinal veins communicate with the basilar plexus at the front of the foramen magnum.

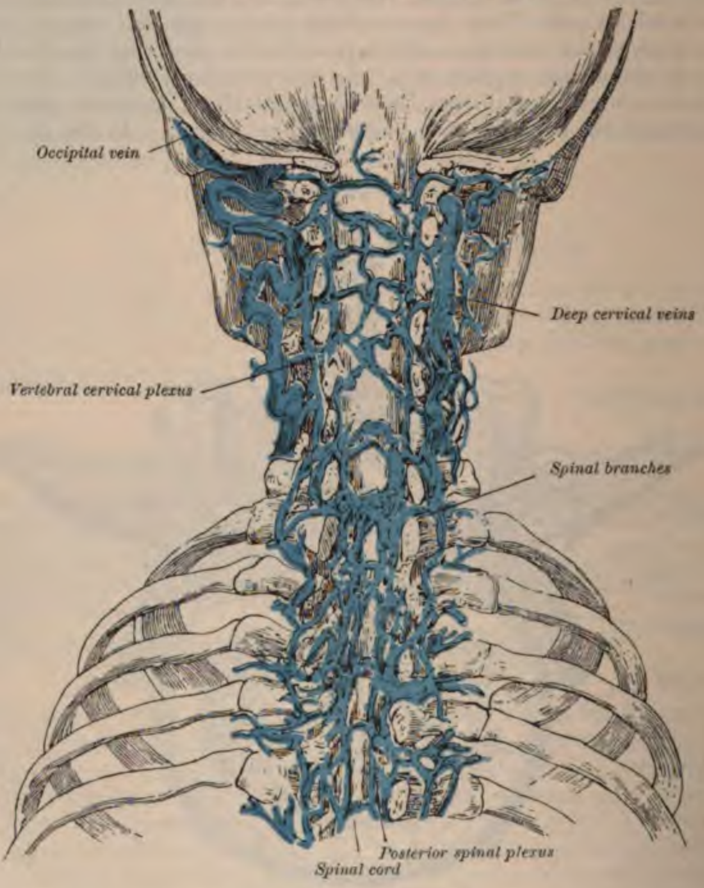
Fig. 487.—The Spinal Veins.


MAMMILLARY PROCESS
ACCESSORY PROCESS OR TIP OF THE TRUE TRANSVERSE PROCESS
COSTAL ELEMENT
Posterior transverse branch
Vein from cord
Transverse branch
Anterior transverse vein
Lumbar vein
Posterior spinal plexus
Branch perforating ligamentum flavum
Posterior longitudinal spinal vein
Lateral transverse branch
Anterior longitudinal spinal vein seen in section
Veins from body of vertebra
BODY
Anterior spinal plexus

The **posterior longitudinal spinal veins,** smaller than the anterior longitudinal veins, likewise extend from the cranium to the coccyx. They lie between the posterior wall of the spinal canal and the dura mater. Like the anterior, they communicate by transverse branches, which receive veins through the ligamenta flava from the dorsal spinal plexus. They also communicate with the anterior longitudinal veins by lateral transverse branches.

It will be thus seen (fig. 487) that in the interior of the vertebral canal, opposite each vertebral segment, there is a venous ring between the bony wall of the canal and the sheath of the dura mater, the ring being formed in front by the anterior transverse vein; on each side by the dilated portion of the trunk of the anterior longitudinal spinal vein and the lateral transverse branch; and behind, by the trunk of the posterior longitudinal vein and the posterior transverse branch. This venous ring receives veins from the body of the vertebra, from the spinal cord, and from the meninges, and pours its blood, in part through the lateral veins lying in the intervertebral foramina into the vertebral, intercostal, lumbar, or sacral veins; and in part through the branch which perforates the ligamenta flava into the dorsal spinal plexus. Above, the posterior longitudinal veins communicate at the back of the foramen magnum with the occipital sinuses. Around the foramen magnum a distinct venous ring or plexus is formed by the communication between the occipital and marginal sinuses and the posterior and anterior spinal veins.

FIG. 488.—THE SPINAL VEINS. (After Henle.)

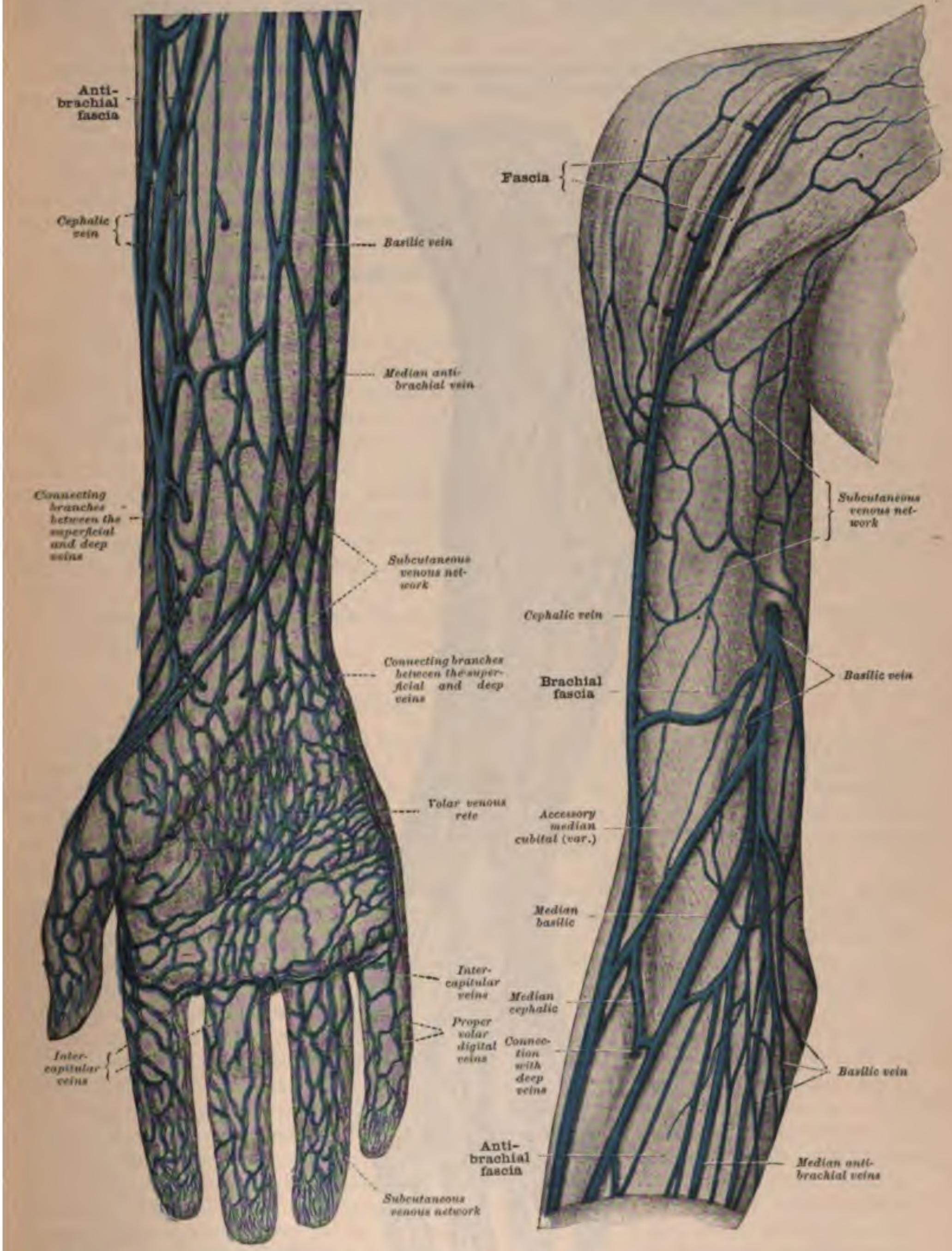


(*b*) The **medullary veins,** or veins of the spinal cord, are of small size, and run in the pia mater in a tortuous course along the spinal cord. They join the venous ring corresponding to each vertebral segment by passing along the sheath of dura mater reflected round the spinal nerves.

THE VEINS OF THE UPPER EXTREMITY

The **veins of the upper limb** consist of two sets—a **superficial** and a **deep.** The superficial veins ramify in the subcutaneous tissue above the deep fascia, and they do not accompany arteries; the deep do accompany the arteries, and have practically the same relations as those vessels. The superficial and deep veins communicate at frequent intervals through the intermuscular veins which run between the muscles and perforate the deep fascia. Both sets of veins are provided with valves, but the valves are more numerous in the deep than in the superficial. There is usually a valve where the deep veins join the superficial. The superficial veins are larger than the deep, and take the greater share in returning the blood.

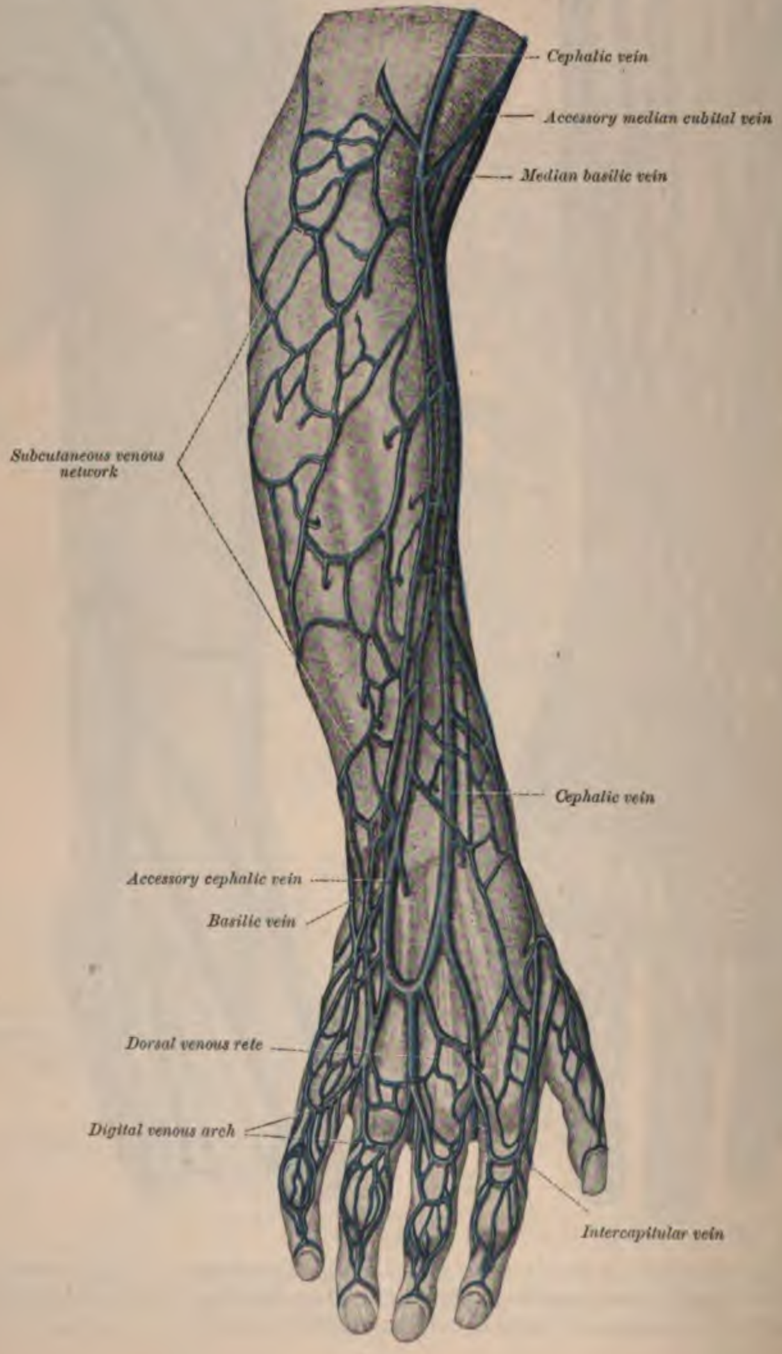
Fig. 489.—The Superficial Veins of the Arm. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Anti-brachial fascia
Cephalic vein
Basilic vein
Median anti-brachial vein
Connecting branches between the superficial and deep veins
Subcutaneous venous network
Connecting branches between the superficial and deep veins
Volar venous rete
Inter-capitular veins
Proper volar digital veins
Inter-capitular veins
Subcutaneous venous network
Fascia
Subcutaneous venous network
Cephalic vein
Brachial fascia
Basilic vein
Accessory median cubital (var.)
Median basilic
Median cephalic
Connection with deep veins
Basilic vein
Anti-brachial fascia
Median anti-brachial veins

I. THE SUPERFICIAL VEINS OF THE UPPER EXTREMITY

The **superficial veins** begin in two irregular plexuses, one in the palm and the other on the back of the hand. The plexus in the palm is much finer, and receives the superficial veins of the fingers, or **proper volar digital** veins, and the veins of

FIG. 490.—VEINS OF THE BACK OF THE FOREARM. (After Toldt, "Atlas of Human Anatomy." Rebman, London and New York.)


Cephalic vein
Accessory median cubital vein
Median basilic vein
Subcutaneous venous network
Cephalic vein
Accessory cephalic vein
Basilic vein
Dorsal venous rete
Digital venous arch
Intercapitular vein

the folds between the fingers, or the **intercapitular** veins. The veins of the back of the hand begin in a longitudinal plexus over the fingers, the **proper dorsal digital** veins, and at the bases of the fingers the veins of each two adjacent digits are connected by a **digital venous arch** from which arise the **dorsal metacarpal veins;** these form upon the back of the hand a dorsal rete.

Of the veins of the arm, two stand out prominently, the basilic and the cephalic. Both of these arise from the veins of the back of the hand, curve around to the volar surface of the forearm, and pass to the upper arm.

The **basilic vein** arises on the back of the hand from the fourth dorsal metacarpal. It curves around the ulnar side of the forearm to the volar surface and passes to the elbow and the upper arm, where it lies in the median bicipital sulcus. It extends up to about the middle third of the sulcus, and then turns into the depth, piercing the brachial fascia, and joins the brachial vein.

The **cephalic vein** begins in the first dorsal metacarpal vein and curves around the radial border of the forearm to the volar surface not far above the thumb. It passes to the elbow and the upper arm, but, unlike the basilic, it maintains its superficial course up to the shoulder, lying first in the lateral bicipital sulcus and then in the groove between the pectoralis major and the deltoid. Just beneath the clavicle it turns into the depth, and uniting with the thoraco-acromial, empties into the axillary vein.

In the forearm plexus one or more longitudinal veins besides these main ones may be distinct. One outside of the cephalic is known as the **accessory cephalic;** one near the centre is known as the **median antibrachial.**

At the elbow there is usually an oblique connecting branch, the **median cubital vein,** which extends from the cephalic up to the basilic, but in other cases this anastomosis is made by a division of the **median antibrachial** into two branches, a **median cephalic** and **median basilic.** A third common arrangement is for the cephalic in the upper arm to be reduced to a branch of a single main forearm vein, which takes the course of the cephalic in the forearm, but bends ulnarwards at the elbow to form the basilic. Numerous connections occur between the deep and the superficial veins at the elbow.

The superficial plexus of veins in the upper arm consists of small vessels that pass to the cephalic vein.

II. THE DEEP VEINS OF THE UPPER EXTREMITY

The **deep veins of the upper extremity** accompany their corresponding arteries. There are two veins to each artery below the level of the axilla, known as the venæ comites. In the leg, as will be afterwards noticed, the venæ comites of the main arteries extend as far as the knee only. The deep veins all contain numerous valves, and communicate at frequent intervals through intermuscular veins with the superficial vessels.

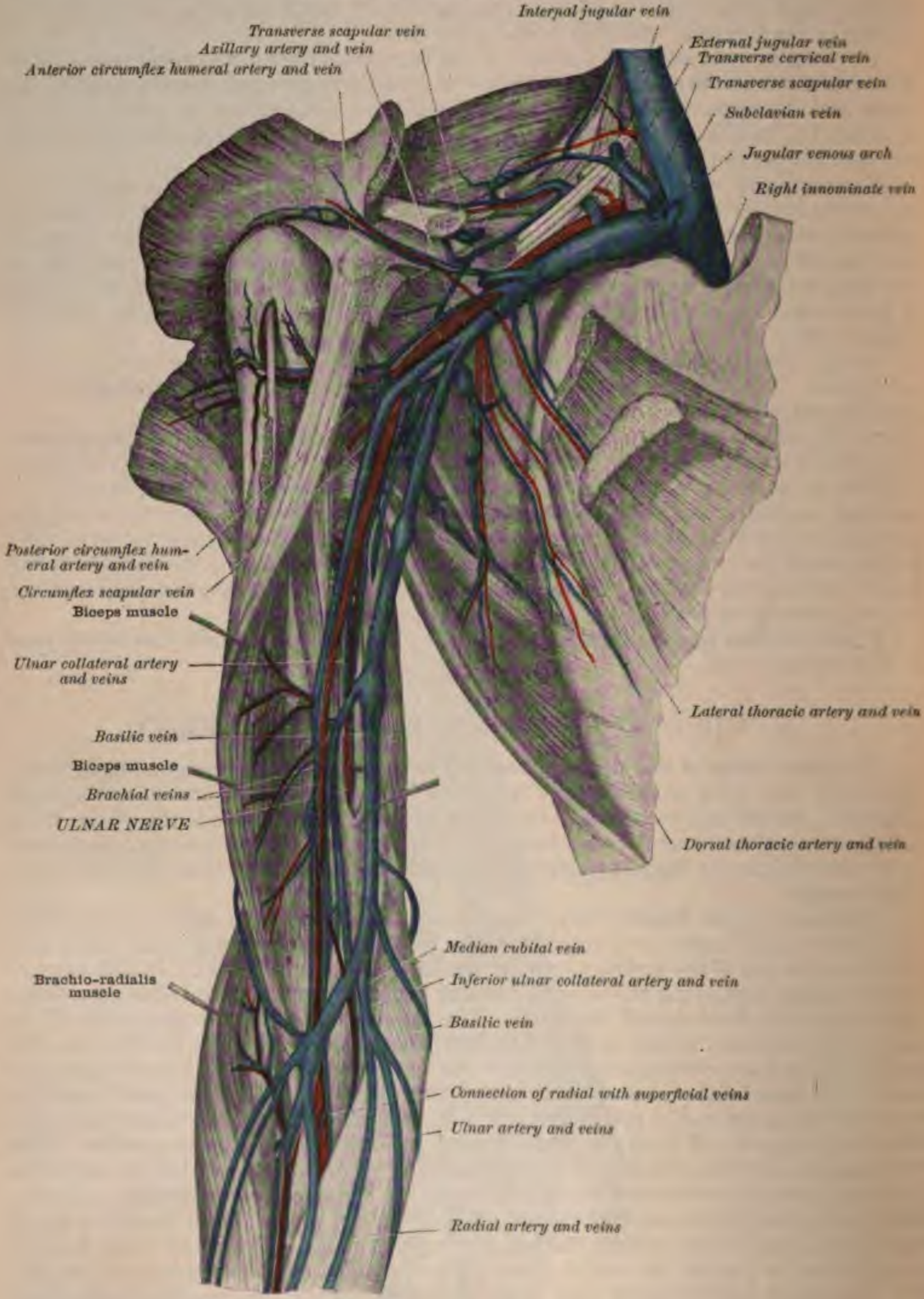
Beginning at the fingers, two minute veins accompany each digital artery along the sides of the fingers, and, uniting at the cleft, form interdigital veins which join the venæ comites of the arteries, forming the superficial palmar arch. In like manner the veins accompanying the arteries forming the deep arch receive tributaries corresponding to the branches of that arch. The venæ comites from the ulnar side of the superficial and deep arches unite at the spot where the ulnar artery divides into the superficial and deep branch to form two ulnar venæ comites; whilst those on the radial side of the superficial and deep arch accompany the superficial volar artery and the termination of the radial artery respectively, and unite at the spot where the superficial volar is given off from the radial artery, to form the radial venæ comites. The ulnar and radial venæ comites thus formed course up the forearm with their respective arteries, receiving numerous tributaries from the muscles amongst which they run, and giving frequent communications to the superficial veins. They finally unite at the bend of the elbow to form the brachial venæ comites. The ulnar venæ comites receive, before joining the radial, the companion veins of the interosseous arteries. At the bend of the elbow the deep veins are connected with the median antibrachial vein by a short, thick trunk.

The **brachial venæ comites** accompany the brachial artery, the inner vein receiving at the lower border of either the teres major or subscapularis muscle, the outer vein and the basilic vein, to form a single axillary vein.

The venæ comites of the arteries of the arm anastomose with one another by frequent cross branches.

The **axillary vein** is formed by the junction of the inner brachial vena comes

FIG. 491.—DEEP VEINS OF THE ARM AND AXILLA. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Internal jugular vein
Transverse scapular vein
Axillary artery and vein
Anterior circumflex humeral artery and vein
External jugular vein
Transverse cervical vein
Transverse scapular vein
Subclavian vein
Jugular venous arch
Right innominate vein
Posterior circumflex humeral artery and vein
Circumflex scapular vein
Biceps muscle
Ulnar collateral artery and veins
Basilic vein
Biceps muscle
Brachial veins
ULNAR NERVE
Lateral thoracic artery and vein
Dorsal thoracic artery and vein
Median cubital vein
Brachio-radialis muscle
Inferior ulnar collateral artery and vein
Basilic vein
Connection of radial with superficial veins
Ulnar artery and veins
Radial artery and veins

with the basilic vein at the lower border of either the teres major or subscapular muscle. It is a vessel of large size, conveying as it does nearly the whole of th returned blood from the upper extremity. It accompanies the axillary arter through the axillary fossa, lying to its inner side and, at the upper part of the space, on a slightly lower plane. At the outer border of the first rib it changes its name to the subclavian. It has one or two axillary lymphatic nodes in close connection with it, and is liable, if care is not taken, to be wounded in removing these glands when infiltrated with cancer secondary to cancer of the breast. The vein contains a pair of valves, usually placed near the lower border of the subscapularis muscle. It receives in its course through the axillary fossa:—(1) The subscapular veins which accompany the subscapular artery; (2) the circumflex veins accompanying the circumflex arteries; (3) the lateral thoracic veins accompanying the lateral thoracic artery; (4) numerous small veins returning the blood from the axillary nodes; (5) the veins corresponding to the branches of the thoraco-acromial axis; and (6) the cephalic vein.

The **subclavian vein** (fig. 491) is the continuation of the axillary. It begins at the outer border of the first rib, and terminates by joining the internal jugular to form the innominate vein opposite the outer part of the sterno-clavicular articulation. It lies anterior to the subclavian artery and on a lower plane, and is separated from the artery in the second part of its course by the scalenus anterior muscle. The subclavian vein, just before the spot where it is joined by the external jugular, contains a pair of valves.

Tributaries.—Near the outer border of the sterno-mastoid muscle it receives the external jugular vein. Occasionally the cephalic vein, or a branch from the cephalic (the jugulo-cephalic), passes over the clavicle to the subclavian.

Chief variations.—(1) The **subclavian vein** may run on a higher plane than usual, lying even above the artery. (2) It may pass with the artery behind the scalenus anterior. (3) It may run behind the scalenus anterior and the artery in front of that muscle. (4) It may split and enclose the scalenus anterior. (5) It may pass between the clavicle and the subclavius. (6) It may receive directly the transverse cervical, the transverse scapular (suprascapular), the anterior jugular, or the cephalic vein, or the venæ comites of the brachial artery.

The development of the veins of the arm.—The earliest vein to form is termed the **marginal vein,** and ascends the ulnar side of the arm. It later becomes the basilic vein. The cephalic vein as well as the other superficial veins are secondary developments, and the deep veins tertiary. It is worthy of note that the cephalic vein primarily passes over the clavicle to unite with the subclavian, a condition which is represented by its jugulo-cephalic branch.

III. VEINS EMPTYING INTO THE INFERIOR VENA CAVA

All the veins of the abdomen, pelvis, and legs, with the exception of the superior epigastric and ascending lumbar vein, which join with the superior caval system, enter directly or indirectly into the inferior vena cava. The veins corresponding to the parietal branches of the abdominal aorta, except the middle sacral vein, open directly into the inferior vena cava; the middle sacral vein only indirectly through the left common iliac vein. Of the visceral veins corresponding to the visceral branches of the abdominal aorta, those which return the blood from the stomach, intestines, pancreas, and the spleen end in a common trunk, the **portal vein,** which enters the liver, breaks up in the liver substance into capillaries like an artery, and from these capillaries arise the hepatic veins which open into the inferior vena cava as that vessel grooves the under surface of the liver.

Of the other visceral veins, both renals, the right suprarenal, and the right spermatic or ovarian open directly into the inferior vena cava; whilst the left suprarenal and left spermatic or ovarian only join that vessel indirectly through the left renal.

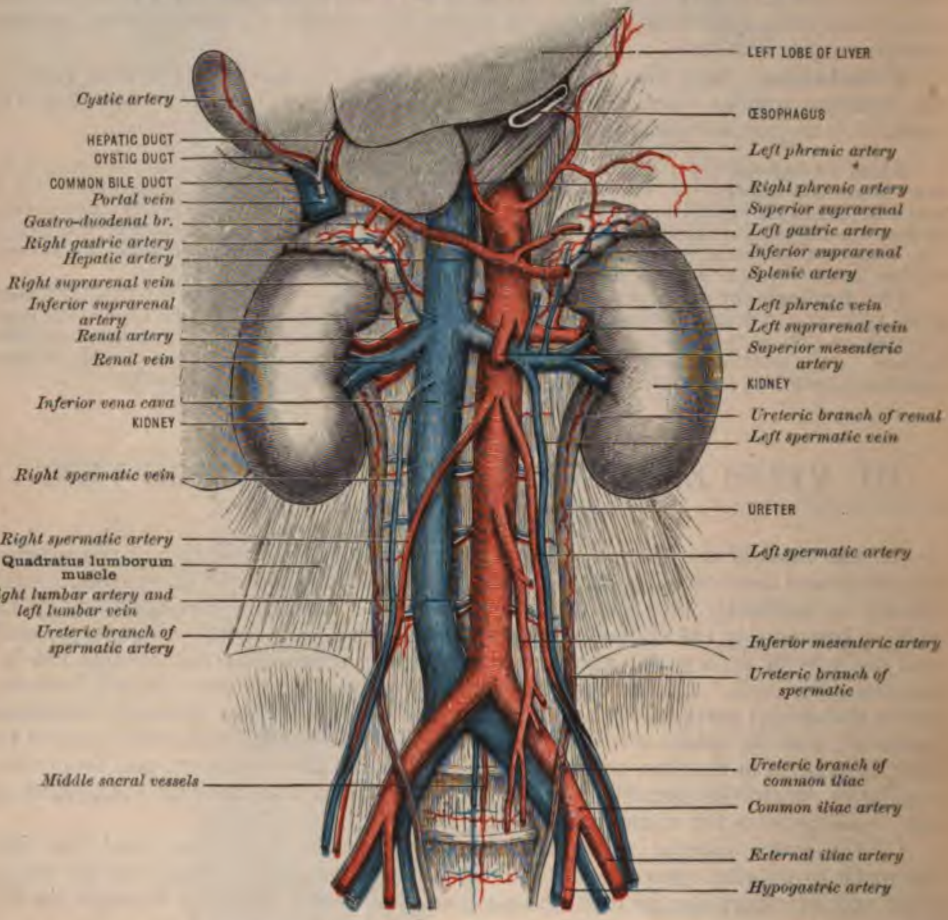
Two of the superficial veins of the lower part of the anterior abdominal wall, the superficial epigastric and superficial circumflex iliac, enter the great saphenous vein; and two of the deep veins from the like situation, the inferior epigastric and deep circumflex iliac, enter the external iliac vein. The blood in these vessels, however, can flow upwards as well as in the normally downward direction. In obstruction of the inferior vena cava they become greatly enlarged, and form, with the superior epigastric vein and with other superficial veins of the thorax with which they anastomose, one of the chief channels for the return of the blood from the lower limbs.

The veins of the pelvis, which receive the veins from the perinæum and gluteal region, join the hypogastric vein.

THE INFERIOR VENA CAVA

The **inferior** or **ascending vena cava** (fig. 492) is the large vessel which returns the blood from the lower extremities and the abdomen and pelvis. It is formed by the confluence of the right and left common iliac veins opposite the body of the fifth lumbar vertebra, ascends in front of the lumbar vertebræ to the right of the abdominal aorta, passes through the caval opening in the diaphragm, and ends in the lower and back part of the right atrium of the heart on a level with the lower border of the ninth thoracic vertebra. At its origin it lies behind the right common iliac artery on a plane posterior to the aorta, but as it ascends it passes slightly forward and to the right, getting on a plane anterior to the aorta, and becoming separated from that artery by the right crus of the diaphragm and the caudate lobe of the liver. While in contact with the liver it lies in a deep groove on the hinder surface of that organ, the groove being often converted into a distinct canal by a thin portion of the hepatic substance bridging across the groove. As it passes through the diaphragm its walls are attached to the tendinous margins of the caval opening, and are thus held apart when the muscle contracts. On the thoracic side of the diaphragm it lies for about 1·2 cm. (½ in.) within the pericardium, the serous layer of that membrane being reflected over it.

Fig. 492.—The Abdominal Aorta and Inferior Vena Cava.


Cystic artery
HEPATIC DUCT
CYSTIC DUCT
COMMON BILE DUCT
Portal vein
Gastro-duodenal br.
Right gastric artery
Hepatic artery
Right suprarenal vein
Inferior suprarenal artery
Renal artery
Renal vein
Inferior vena cava
KIDNEY
Right spermatic vein
Right spermatic artery
Quadratus lumborum muscle
Right lumbar artery and left lumbar vein
Ureteric branch of spermatic artery
Middle sacral vessels
LEFT LOBE OF LIVER
ŒSOPHAGUS
Left phrenic artery
Right phrenic artery
Superior suprarenal
Left gastric artery
Inferior suprarenal
Splenic artery
Left phrenic vein
Left suprarenal vein
Superior mesenteric artery
KIDNEY
Ureteric branch of renal
Left spermatic vein
URETER
Left spermatic artery
Inferior mesenteric artery
Ureteric branch of spermatic
Ureteric branch of common iliac
Common iliac artery
External iliac artery
Hypogastric artery

Relations.—**In front** it is covered by the peritoneum, and crossed by the right spermatic artery, branches of the aortic plexus of the sympathetic, the transverse colon, the root of the mesentery, the duodenum, the head of the pancreas, the portal vein, and the liver. The median group of the lumbar lymphatic nodes are also in front of it below, and at its commencement the right common iliac artery rests upon it.

Behind, it lies on the lumbar vertebræ, the right lumbar arteries, the right renal artery, the right cœliac (semilunar) ganglion, and the right crus of the diaphragm.

To the **right** are the peritoneum, liver, and psoas muscle.

To the **left** is the aorta, and higher up the right crus of the diaphragm.

Tributaries.—The inferior vena cava receives the following veins:—(1) the renal veins; (2) the right suprarenal vein; (3) the right spermatic or (4) the right ovarian vein; (5) the lumbar veins; (6) the inferior phrenic veins; (7) the hepatic veins; and (8) the right and left common iliac veins.

(1) The **renal veins** return the blood from the kidneys. They are short but thick trunks, and open into the vena cava nearly at right angles to that vessel. The vein on the left side, like the kidney, is a little higher than on the right, and is also longer, in consequence of its having to cross the aorta. The comparative shortness of the right renal vein should be borne in mind in the operation of nephrectomy, since, if too much traction is made on the pedicle, not only the vein, but a portion of the vena cava may be drawn into the ligature, as shown in a specimen in St. Bartholomew's Hospital Museum. Each vein lies in front of its corresponding artery. The left vein crosses in front of the aorta, just below the origin of the superior mesenteric artery. It is covered by the third portion of the duodenum, and receives the left spermatic, or the left ovarian in the female, and usually the left suprarenal, and sometimes the left phrenic. There are rudiments of valves in each vein where it joins the vena cava. Those on the right side, however, are less well marked.

(2) **The suprarenal veins.**—There is usually only one suprarenal vein on each side to return the blood brought to the suprarenal body by the three suprarenal arteries. On the **right side** the vein opens into the vena cava direct, above the opening of the right renal vein. On the **left side,** it opens into the left renal.

(3) The **spermatic veins** return the blood from the testis. They begin by the confluence of small branches from the body of the testis and epididymis, and as they proceed up the spermatic cord, in front of the spermatic artery and vas deferens, become dilated and plexiform, constituting the so-called **pampiniform plexus.** After passing through the subcutaneous inguinal ring, the inguinal canal, and the abdominal inguinal ring, the plexus merges into two veins, which lie one on each side of the spermatic artery. Along with the artery the veins pass up beneath the peritoneum, and on the left side also beneath the sigmoid colon, across the psoas muscle and ureter, to end as a single trunk, on the right side in the inferior vena cava, and on the left side in the left renal vein. There are commonly a number of imperfect valves in the spermatic plexus and a perfect pair at the termination of each spermatic vein. On the left side, however, the terminal valve may be wanting.

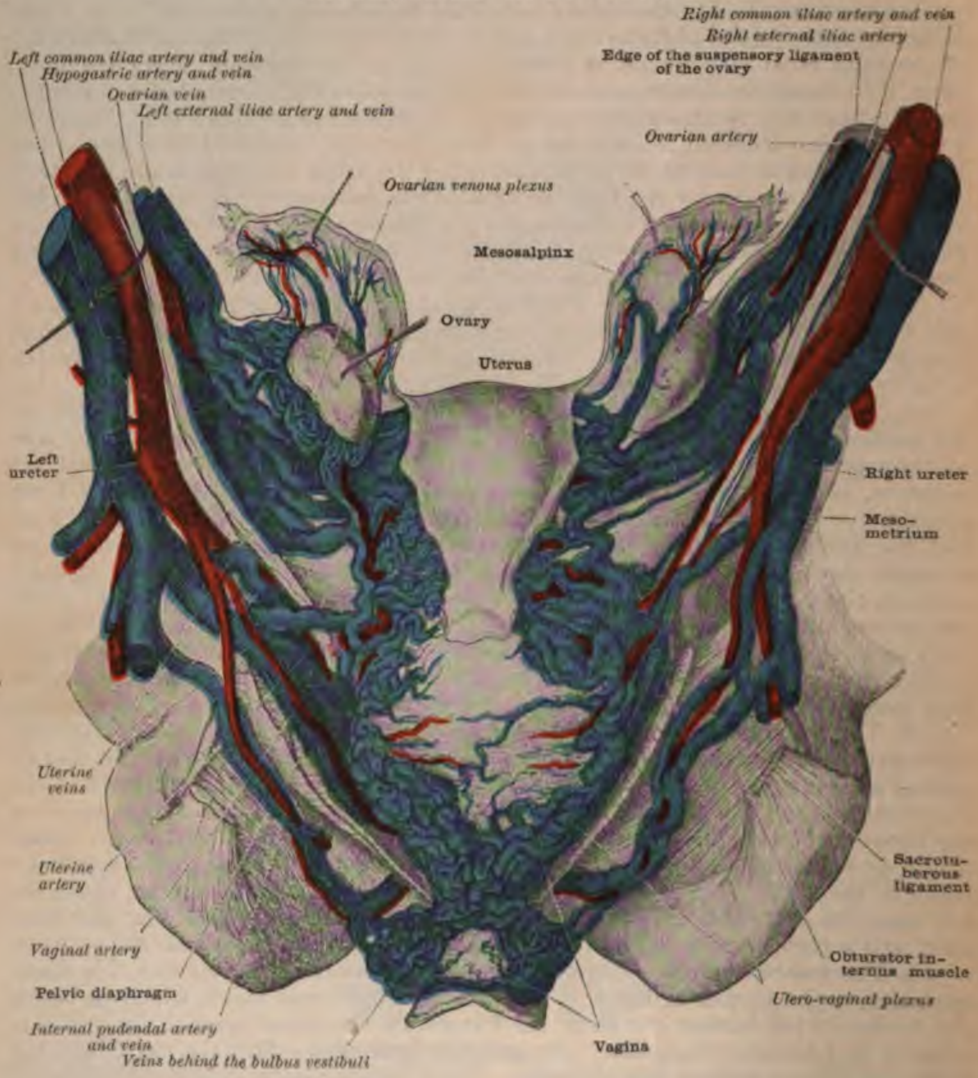
(4) The **ovarian veins** begin at the pampiniform plexus near the ovary, between the layers of the broad ligament. This plexus communicates freely with the uterine plexus of veins, and with the plexus of veins which extends from the hilus of the ovary into the ovarian ligament (fig. 450). After passing from between the layers of the broad ligament, the plexus unites to form at first two and then a single vessel, which accompanies the ovarian artery, following a similar course to the spermatic veins in the male. The right ovarian vein opens into the inferior vena cava; the left into the left renal. They usually contain imperfect valves in their plexiform part, and a perfect valve where they join the vena cava and renal vein respectively.

(5) **The lumbar veins.**—There are usually four lumbar veins on each side corresponding to the lumbar arteries. The main trunks of these veins, which lie beside the bodies of the lumbar vertebræ, are formed by the union beneath the psoas of anterior and posterior branches. The **anterior branches** collect the blood from the front and lateral walls of the abdomen. They communicate in front with the internal mammary and epigastric veins, and then run backwards between the abdominal muscles in company with the anterior branches of the lumbar arteries to their confluence with the posterior branches. The **posterior branches** collect the blood from the loins and muscles of the back, and correspond to the posterior or dorsal division of the lumbar arteries. They receive communicating branches from the dorsal spinal plexus and from the vertebral canal, and pass forwards between the transverse processes to join the anterior branches. The trunk lumbar veins are connected beneath the psoas muscle by vertical branches, which cross in front of the transverse processes. The last lumbar vein is variously joined below by a vertical branch to the common iliac, hypogastric (internal iliac), lateral sacral or ilio-lumbar

vein, and the first lumbar vein is similarly connected above with the commencement of the vena azygos (major) on the right, and the vena hemiazygos on the left side. The vertical vein thus formed is known as the **ascending lumbar vein.** The trunk lumbar veins run up beneath the tendinous arches of the psoas on the sides of the bodies of the vertebræ in company with the lumbar arteries and branches of the sympathetic nerve, and end in the inferior vena cava on its posterior aspect. The left veins are longer than the right, and pass behind the aorta.

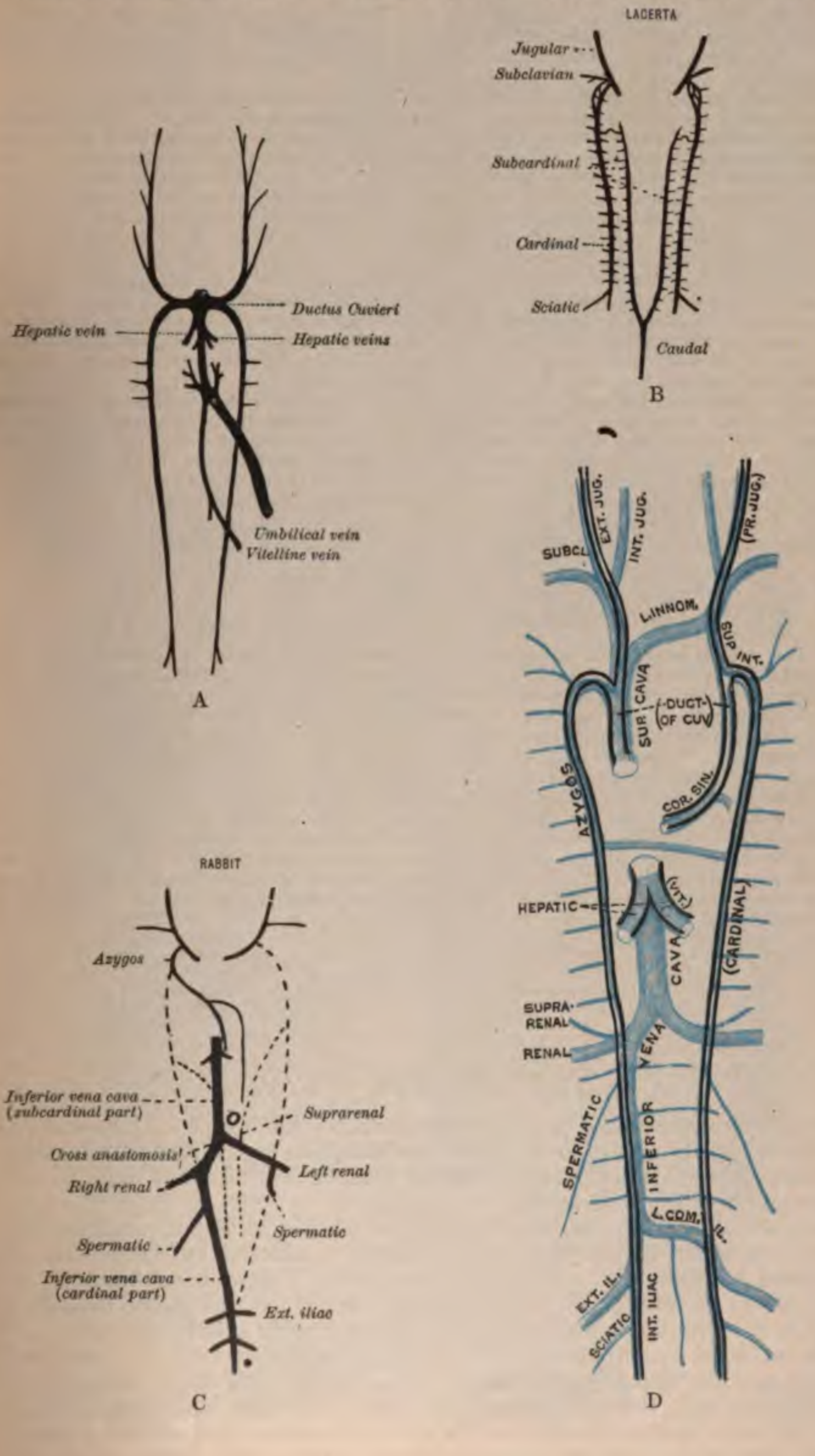
(6) The **inferior phrenic veins** follow the course of the phrenic arteries: the right opens into the vena cava direct; the left into the suprarenal, the left renal, or the vena cava.

FIG. 493.—THE VEINS OF THE FEMALE PELVIS. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Right common iliac artery and vein
Right external iliac artery
Edge of the suspensory ligament of the ovary
Left common iliac artery and vein
Hypogastric artery and vein
Ovarian vein
Left external iliac artery and vein
Ovarian artery
Ovarian venous plexus
Mesosalpinx
Ovary
Uterus
Left ureter
Right ureter
Meso-metrium
Uterine veins
Uterine artery
Sacrotuberous ligament
Vaginal artery
Obturator internus muscle
Pelvic diaphragm
Utero-vaginal plexus
Internal pudendal artery and vein
Veins behind the bulbus vestibuli
Vagina

(7) The **hepatic veins,** the largest tributaries of the vena cava, return the blood from the liver. Commencing in the substance of the liver (see LIVER), they converge as they approach its posterior surface, and unite to form two or three large branches, which open into the vena cava as it lies in the groove or canal in that organ. Some smaller vessels from the caudate lobe, and other parts of the liver in the neighbourhood of the caval groove, open directly into the vena cava. The hepatic veins contain no valves, but, in consequence of those from the right and left

FIG. 494.—A. THE VEINS OF A FOUR WEEKS' FŒTUS. (Modified from Quain). B. THE PRIMITIVE VEINS OF THE LIZARD. (After Hochstetter.) C. THE VEINS OF THE RABBIT. (After Hochstetter and Lewis.) D. DIAGRAM OF THE VENOUS CIRCULATION. (After Quain.)


LACERTA
Jugular
Subclavian
Subcardinal
Cardinal
Sciatic
Caudal
B
Ductus Cuvieri
Hepatic vein
Hepatic veins
Umbilical vein
Vitelline vein
A
RABBIT
Azygos
Inferior vena cava (subcardinal part)
Suprarenal
Cross anastomosis
Left renal
Right renal
Spermatic
Spermatic
Inferior vena cava (cardinal part)
Ext. iliac
C
EXT. JUG.
INT. JUG.
(PR. JUG.)
SUBCL.
L.INNOM.
SUP. INT.
SUP. CAVA
(DUCT. OF CUV.)
AZYGOS
COR. SIN.
HEPATIC
(VIT.)
(CARDINAL)
SUPRA-RENAL
RENAL
INFERIOR VENA CAVA
SPERMATIC
L.COM. IL.
EXT. IL.
INT. ILIAC
SCIATIC
D

lobe of the liver opening obliquely into the vena cava, a semilunar fold occurs at the lower margins of their orifices.

The development of the inferior vena cava.—Primarily the blood from the regions drained by the inferior vena cava, with the exception of that from the liver, flows into the cardinal veins and so to the ductus Cuvieri (p. 643, fig. 494 A). The hepatic veins, however, open into the upper part of a vein known as the **ductus venosus** (p. 685), which in turn opens into the right atrium. This upper portion of the ductus venosus becomes the upper portion of the adult inferior vena cava.

At an early age a longitudinal stem lying parallel to the abdominal portion of each cardinal vein developes by the anastomoses of veins from the mesentery (fig. 494 B). These stems are known as the **subcardinal veins,** and are united with the neighbouring cardinals by numerous cross branches, and, in addition, that of the right side unites with the ductus venosus just below the point where that vein receives the hepatic veins. Later several connections develope between the two subcardinal veins, from the level of the renal veins to that of the common iliacs, and through them the blood returning by the left renal, lumbar, and common iliac veins passes to the right subcardinal and, through its connection with the ductus venosus, into that vessel (fig. 494 C). The portions of the cardinals below the level of the renal veins eventually disappear, as does also the portion of the left subcardinal below the level of the left spermatic (ovarian) vein, and the right subcardinal becomes the lower portion of the inferior vena cava. The large cross connection between the two subcardinals opposite the entrance of the renal veins becomes the portion of the left renal vein which extends across the vertebral column, and since a persisting portion of the left subcardinal forms the terminal portion of the left spermatic (ovarian) vein, that vein opens in the adult into the left renal (fig. 494 C).

It will be seen from the above description that the portion of the inferior vena cava above the entrance of the renal veins is from the beginning an unpaired stem, composed of a portion of the ductus venosus and the communication of the right subcardinal with that vessel. Below the entrance of the renals, however, there are originally the paired subcardinals, and if the left one should fail to disappear, this lower portion of the inferior cava would be paired, or the right subcardinal might disappear while the left persisted, in which case there would be a single inferior cava, but it would be situated on the left side of the vertebral column. Rarely the cardinals may persist, the inferior caval blood then passing by the azygos veins with the superior vena cava.

Chief Variations in the Inferior Vena Cava

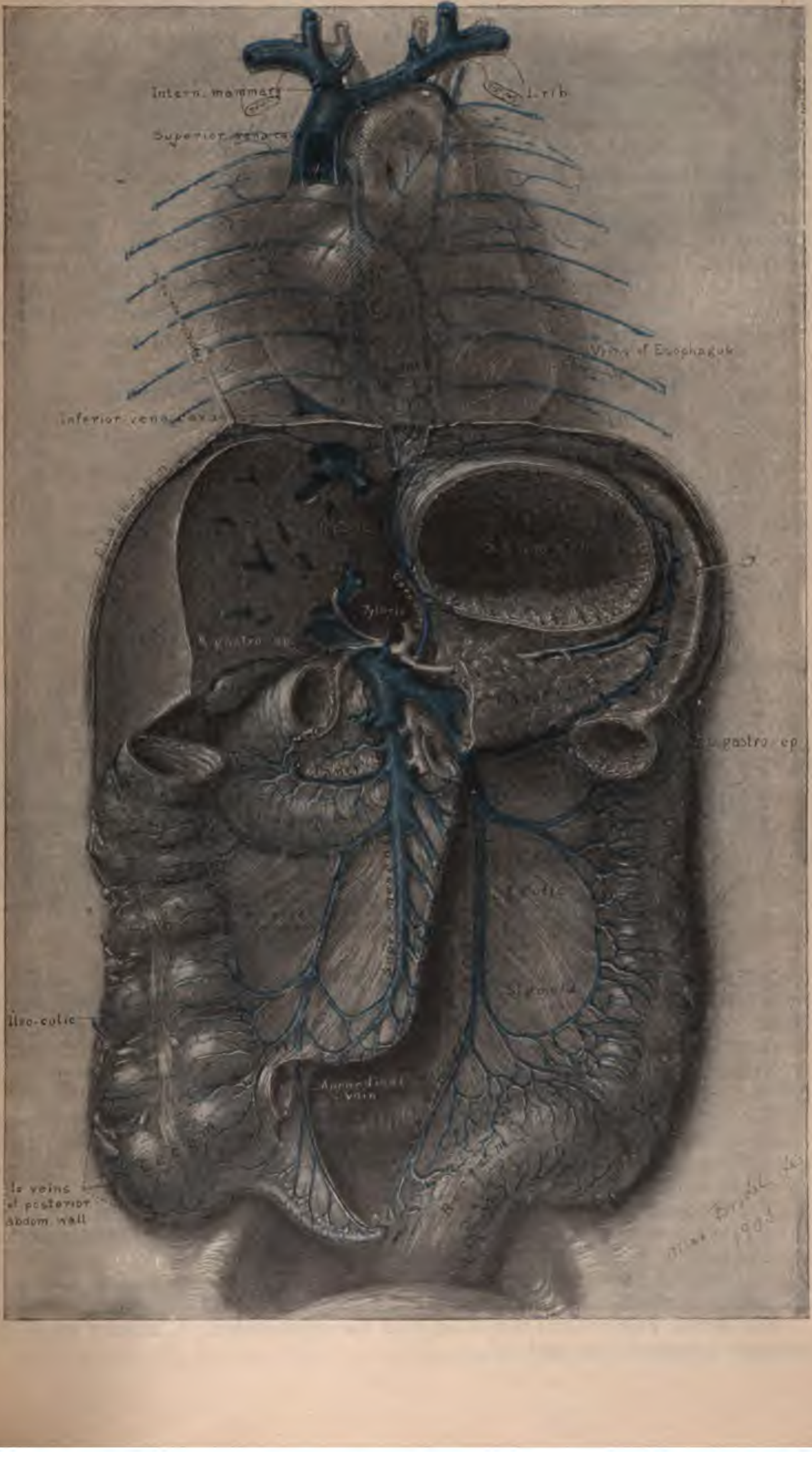
(1) The inferior vena cava, in cases of transposition of the viscera, may lie on the left side of the aorta. (2) Without transposition it may also lie to the left of the aorta, crossing to the right to gain the caval opening immediately below the diaphragm, or after receiving the left renal vein. (3) It may be double, the left cava then usually passing across the aorta into the right after receiving the left renal vein. A communication between the right and left veins in the position of the normal left common iliac vein may or may not then exist. (4) The inferior vena cava may be absent, the blood from the lower extremities passing by a large vein in the position of the ascending lumbar and azygos veins through the diaphragm to open into the superior vena cava. The hepatic veins then open directly into the right auricle through the normal caval opening in the diaphragm. (5) The inferior vena cava may receive the left spermatic vein. (6) It may receive a left accessory renal vein passing behind the aorta, and into this the usual tributaries of the left renal vein may open. (7) It may receive several accessory renal veins; as many as seven on each side have been met with. (8) The lumbar veins may enter it on one or both sides as a common trunk.

THE PORTAL VEIN

The veins corresponding to the inferior mesenteric, the superior mesenteric, and the branches of the cœliac artery, with the exception of the terminal branches of the hepatic artery, do not join the inferior vena cava direct, but unite to form a common trunk—the **portal vein.**

This vein enters the liver, and breaks up in its substance into capillaries like an artery, from which the blood is again ultimately collected by the hepatic veins and carried by them into the inferior vena cava. The terminal branches of the hepatic artery also empty into the same capillaries, and their blood likewise finds its way finally into the hepatic veins, and thence into the inferior vena cava. Thus the arterial blood, leaving the aorta for the supply of the stomach, the intestines, the pancreas, and the spleen, passes, before it reaches the vena cava, through two sets of capillaries, viz., the capillaries of the viscera and the capillaries of the liver. Hence the portal system of veins may be said to terminate in capillaries at each end, to begin, like other veins, in capillaries in the viscera; but, unlike other veins, t

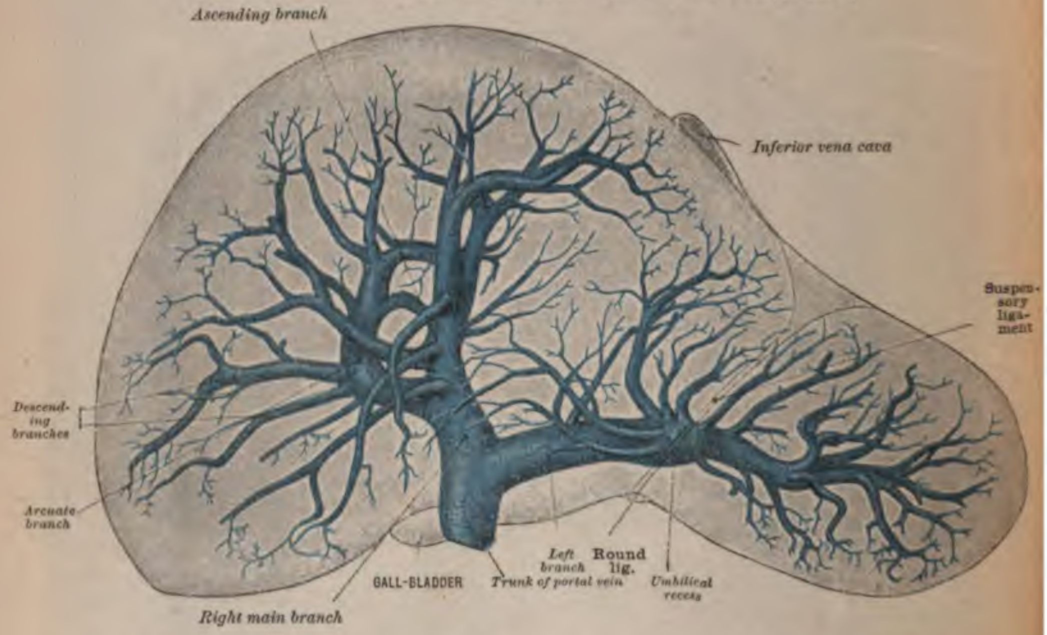
FIG. 495.—THE PORTAL VEIN. (From Kelly, by Brödel.)


Intern. mammary
1. rib
Superior vena ca
Veins of Esophagus
Inferior vena cava
Pylorus
R. gastro-ep.
gastro-ep.
Sigmoid
Ileo-colic
Appendical vein
le veins of posterior abdom. wall
Max Brödel

end in capillaries like an artery, instead of in a larger and larger vein till the atrium is reached. The portal vein and its tributaries have no valves.

The **portal vein** is a thick trunk 7 or 8 cm. (3 in.) in length. It is formed behind the head of the pancreas, opposite the right side of the body of the second lumbar vertebra, by the union of the superior mesenteric with the splenic vein. After passing behind the first part of the duodenum, and then between the layers of the lesser omentum in company with the hepatic artery and the hepatic duct, it enters the portal fissure of the liver, and there divides into a right and a left branch. In this course it passes upwards and to the right, having both the hepatic artery and the common bile duct in front, the former to the left, the latter to the right. It is surrounded by branches of the hepatic plexus of the sympatheic nerve, and by numerous lymphatic vessels and some glands. The connective tissue sheath enclosing these structures is called the capsule of Glisson. Just before it divides it is somewhat dilated, the dilated portion being called the **sinus of the portal vein.** The division into right and left branches takes place towards the right end of the portal fissure of the liver. The **right branch** is shorter and thicker than the left, and supplies the right lobe of the liver and a branch to the quadrate lobe. The **left branch** is longer and smaller than the right, and supplies the left lobe, and gives a branch to the caudate (Spigelian) and quadrate lobes. It is joined, as it crosses the longitudinal fissure, by a fibrous cord, known as the round ligament of the liver or the obliterated umbilical vein, and posteriorly by a second fibrous cord, the remains of the ductus venosus (see p. 685).

FIG. 496.—THE PORTAL VEIN WITHIN THE LIVER. (After Rex.)



Tributaries.—The pyloric, the coronary (gastric), the cystic (which latter usually enters the right branch), the superior mesenteric, and the splenic.

The **pyloric vein** begins near the pylorus in the lesser curve of the stomach, and, running from left to right with the right gastric (superior pyloric) artery, ope[illegible] directly into the lower part of the portal vein. It receives branches from the pa[illegible]creas and duodenum.

The **coronary** or **gastric vein** runs with the left gastric artery at first from rig[illegible] to left, along the lesser curvature of the stomach, towards the cardiac end, and the[illegible] turning to the right, passes across the spine from left to right to end in the port[illegible] trunk a little higher than the pyloric vein (fig. 497). At the cardiac end of t[illegible] stomach it receives small branches from the œsophagus.

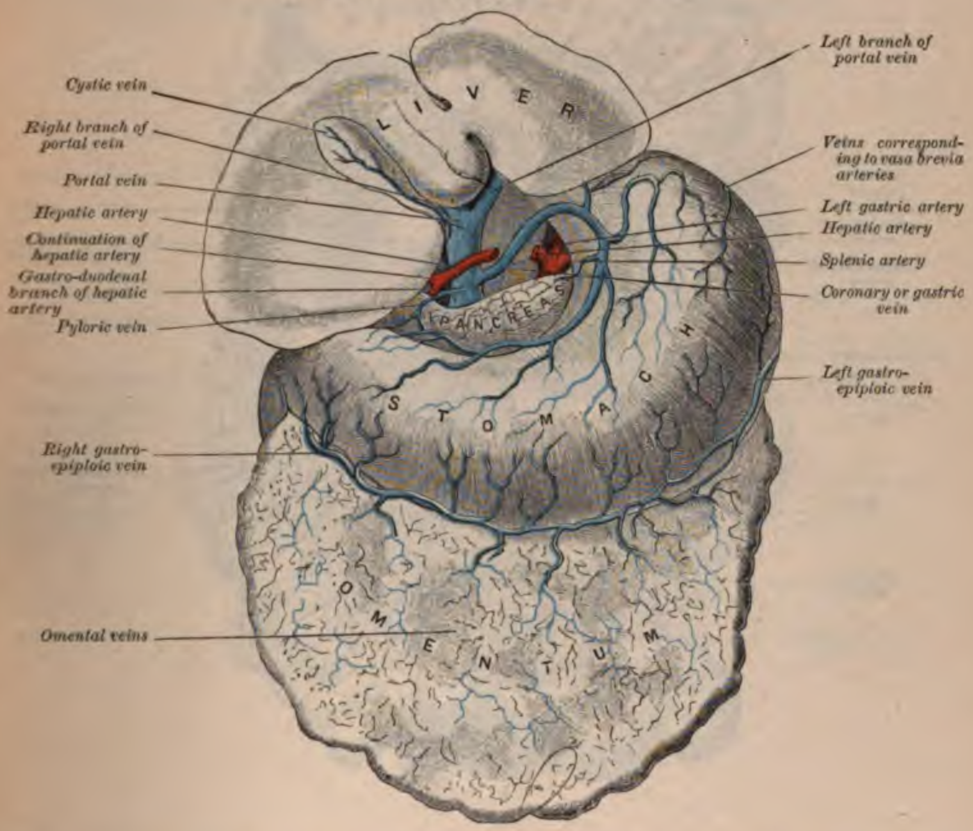
The **cystic vein** returns the blood from the gall-bladder. It usually opens in[illegible] the right branch of the portal vein.

The **superior mesenteric vein** begins in tributaries which correspond with the branches of the superior mesenteric artery. It courses upwards a little, in front and to the right of the artery, passing with that vessel from between the layers of the mesentery in front of the duodenum, and behind the pancreas, where it joins the splenic vein to form the portal trunk (fig. 498).

Tributaries.—In addition to the tributaries corresponding to the branches of the superior mesenteric artery—viz. the ileo-colic, right colic, middle colic, and small intestinal veins (fig. 498)—it receives the **right gastro-epiploic** and the **pancreatico-duodenal veins** just before its termination in the portal vein.

The **right gastro-epiploic vein** accompanies the artery of that name. It runs from left to right along the greater curvature of the stomach, receiving branches from the anterior and posterior surfaces of that viscus, and from the great omentum, and, passing behind the first portion of the duodenum, ends in the superior mesenteric vein just before that vessel joins the portal trunk.

FIG. 497.—THE VEINS OF THE STOMACH AND THE PORTAL VEIN. (From a dissection by W. J. Walsham.)


Cystic vein
Right branch of portal vein
Portal vein
Hepatic artery
Continuation of hepatic artery
Gastro-duodenal branch of hepatic artery
Pyloric vein
Right gastro-epiploic vein
Omental veins
Left branch of portal vein
Veins corresponding to vasa brevia arteries
Left gastric artery
Hepatic artery
Splenic artery
Coronary or gastric vein
Left gastro-epiploic vein
LIVER
PANCREAS
STOMACH
OMENTUM

The **pancreatico-duodenal vein** runs with the corresponding arteries between the head of the pancreas and the second portion of the duodenum, and ends in the superior mesenteric vein a little below the spot where that vessel is joined by the right gastro-epiploic vein.

The **splenic vein** issues as several large branches from the hilus of the spleen. These soon unite to form a large trunk, which passes across the aorta and spine in company with the splenic artery, below which it lies, to join at nearly a right angle the superior mesenteric vein. In this course it lies behind the pancreas; and at its union with the superior mesenteric to form the vena porta, in front of the inferior vena cava.

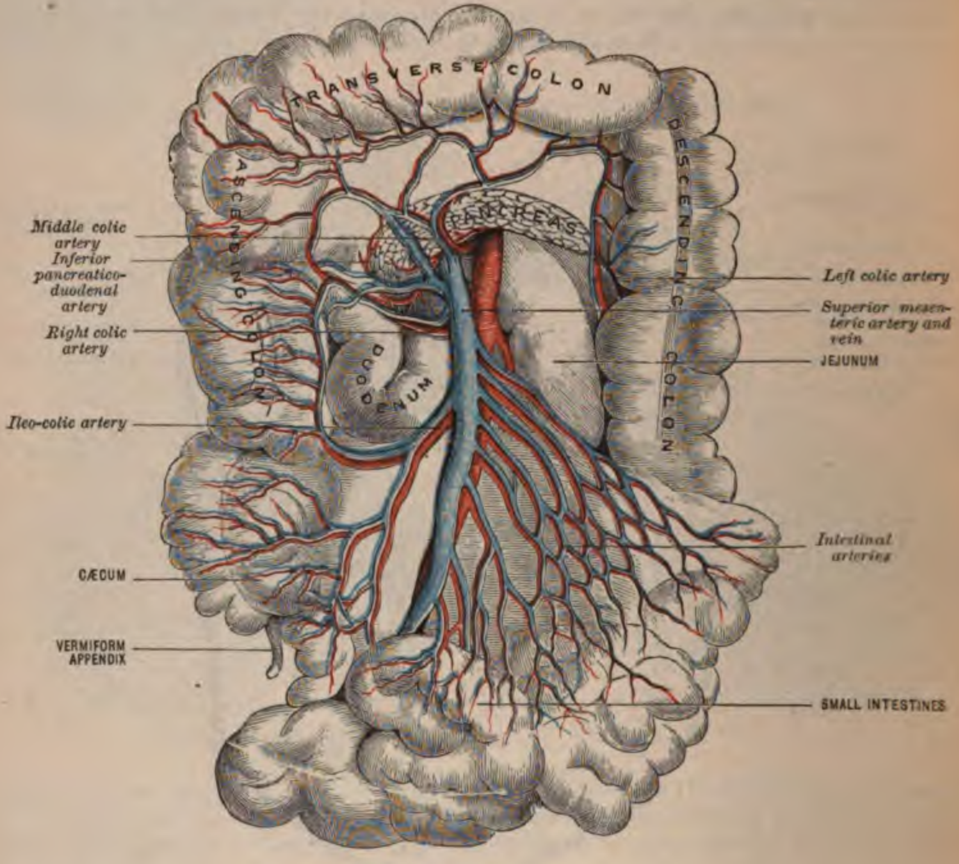
Tributaries.—It receives veins corresponding to the **short gastric arteries**

from the cardiac end of the stomach, the **left gastro-epiploic vein,** veins from the **pancreas,** and the **inferior mesenteric vein.**

The **left gastro-epiploic vein** accompanies the left gastro-epiploic artery. It runs from right to left along the greater curvature of the stomach, receives branches from the stomach and omentum, and opens into the commencement of the splenic vein.

The **inferior mesenteric vein** begins at the rectum in the superior and middle hæmorrhoidal veins. It passes out of the pelvis with the inferior mesenteric artery; but, after receiving the veins corresponding with the sigmoid and left colic branches of that vessel, it leaves the artery and runs upwards on the psoas to the left of the aorta and behind the peritoneum. On approaching the pancreas it turns slightly inwards, and passes obliquely behind that gland to join the splenic vein just before the latter unites with the superior mesenteric to form the vena porta.

FIG. 498.—THE SUPERIOR MESENTERIC VEIN.
(The colon is turned up, and the small intestines are drawn over to the left side.)


TRANSVERSE COLON
ASCENDING COLON
DESCENDING COLON
PANCREAS
DUODENUM
Middle colic artery
Inferior pancreatico-duodenal artery
Right colic artery
Ileo-colic artery
CÆCUM
VERMIFORM APPENDIX
Left colic artery
Superior mesenteric artery and vein
JEJUNUM
Intestinal arteries
SMALL INTESTINES

The accessory portal veins.—Since the blood returning from the abdominal portion of the digestive tract and spleen must pass through the hepatic capillaries before returning to the heart, extensive obliteration of these capillaries, such as occurs in certain diseases of the liver, would prevent the return of the portal blood to the heart were it not for anastomoses between tributaries of the portal vein and those of the caval systems, constituting what have been termed accessory portal veins. Some of the more important of these are—(1) between the branches of the coronary vein of the stomach and the œsophageal veins which open into the vena azygos; (2) between the **parumbilical veins,** which communicate with the portal vein above and descend the anterior abdominal wall to anastomose with the deep epigastric and superior vesical veins; (3) between the superior and middle hæmorrhoidal veins, the latter opening into the hypogastric.

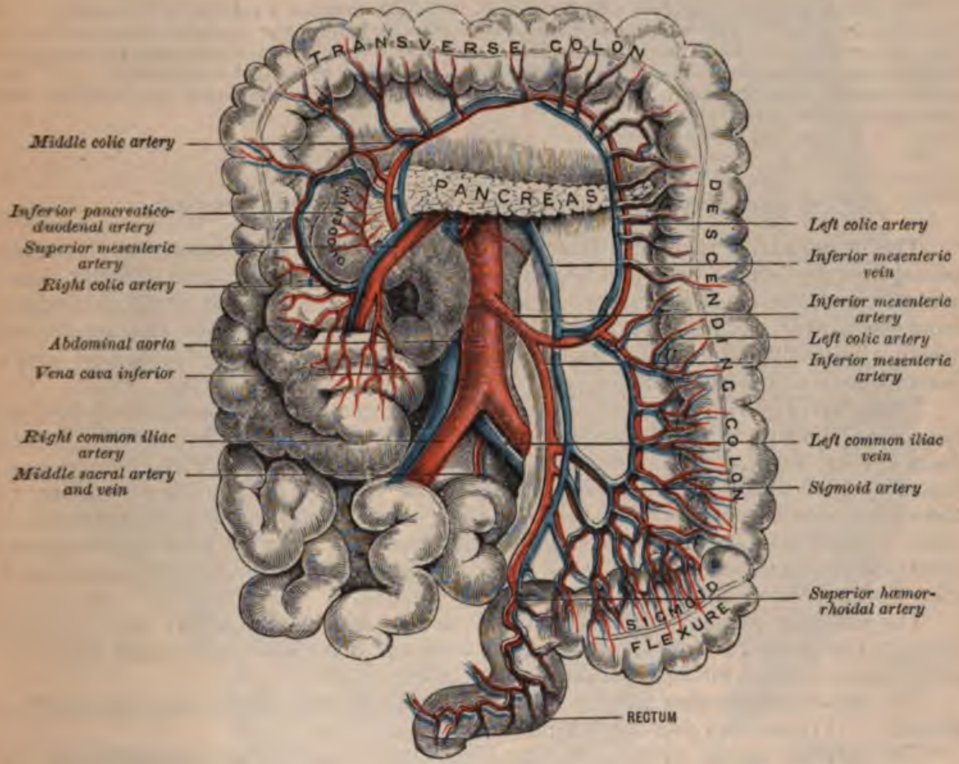
The Development of the Portal Vein

At an early stage of development two sets of veins enter the body of the embryo at what will later be the umbilicus. These are the two **umbilical** and **omphalo-mesenteric** veins, the former returning the blood from the placenta and the latter from the yolk-sac, also receiving the veins from the intestine. At first both sets of veins open into the ductus Cuvieri, but on the development of the liver the omphalo-mesenteric veins break up into a network in its substance, and with this network the umbilical veins also communicate. Between the point where the right omphalo-mesenteric joins the ductus Cuvieri and the communication of the left umbilical with the hepatic network, a large channel, the **ductus venosus,** is developed from the network, and, the upper portion of the left umbilical vein disappearing, the ductus becomes its continuation. Subsequently the right umbilical vein completely disappears and by a complicated series of changes the two omphalo-mesenterics become reduced to a single stem which drains the abdominal portion of the digestive tract and becomes the portal vein.

The hepatic veins now develope, placing the hepatic network in communication with the terminal portion of the ductus venosus, and, after birth, the remainder of the ductus degenerates, so that all the blood passing to the liver must pass through the portal capillaries and so to the hepatic veins. The terminal portion of the ductus venosus, above the entrance of the hepatic veins, becomes the upper part of the inferior vena cava (see p. 680).

Fig. 499.—The Inferior Mesenteric Vein.

(The colon is turned up, and the small intestines are drawn to the right side.)


TRANSVERSE COLON
Middle colic artery
PANCREAS
DUODENUM
Inferior pancreatico-duodenal artery
Superior mesenteric artery
Right colic artery
Abdominal aorta
Vena cava inferior
Right common iliac artery
Middle sacral artery and vein
DESCENDING COLON
Left colic artery
Inferior mesenteric vein
Inferior mesenteric artery
Left colic artery
Inferior mesenteric artery
Left common iliac vein
Sigmoid artery
Superior hæmorrhoidal artery
SIGMOID FLEXURE
RECTUM

After birth the persistent left umbilical vein, having lost its original function, becomes converted into the round ligament of the liver (see Section VIII), slight traces of its original lumen frequently persisting in the upper part of the ligament.

THE COMMON ILIAC VEINS

The **common iliac veins** are formed opposite the sacro-iliac synchondrosis by the confluence of the external iliac and hypogastric (internal iliac) veins. They converge as they ascend, and unite opposite the upper border of the fifth lumbar vertebra and a little to the right of the median line to form the inferior vena cava.

The **right vein,** shorter and more vertical in direction than the left, passes obliquely behind the right common iliac artery to its outer side, where it is joined by the left common iliac vein.

The **left vein** lies to the inner side of the left common iliac artery, and, after crossing in front of the promontory of the sacrum and the fifth lumbar vertebra below the bifurcation of the aorta, passes beneath the right common iliac artery to join the right vein and form the inferior vena cava. The left vein may contain an imperfect valve.

Tributaries.—The ilio-lumbar veins may enter the lower part of the common iliac, or open into the hypogastric (internal iliac) vein. The left vein receives the middle sacral veins.

(*a*) The **ilio-lumbar vein** follows the course of the ilio-lumbar artery, and ends either in the common iliac or in the internal iliac vein.

(*b*) The **middle sacral veins** ascend on either side of the middle sacral artery in front of the sacrum, to open usually by a single trunk into the left common iliac vein. They communicate with the lateral sacral veins, forming the **anterior sacral plexus.** Below, the middle sacral veins communicate with the hæmorrhoidal veins.

Chief Variations in the Common Iliac Veins

(1) Either common iliac vein may be double, or double only for a portion of its extent. (2) One may be absent,—the external and internal iliac veins joining the opposite common iliac to form the vena cava. (3) The right and left internal iliac veins may unite and open as a common trunk at the confluence of the right and left external iliac veins to form the vena cava. (4) The middle sacral trunk vein may divide, and one branch open into the right, and the other into the left common iliac vein.

THE HYPOGASTRIC (INTERNAL ILIAC) VEIN

The **hypogastric (internal iliac) vein** is formed by the confluence of the veins (except the umbilical) corresponding to the branches of the hypogastric (internal iliac) artery. It varies considerably in length, but is usually quite a short trunk, extending from the upper part of the great sacro-sciatic foramen to the sacro-iliac synchondrosis, where it joins the external iliac to form the common iliac vein. It lies behind and a little internal to the internal iliac artery. It contains no valve.

Tributaries.—The internal iliac vein receives directly or indirectly the following branches: the superior gluteal, ilio-lumbar, lateral sacral, obturator, inferior gluteal (sciatic), and internal pudic veins, and also branches from the pudendal, vesical, and hæmorrhoidal plexuses. The **single umbilical vein**—the vein corresponding to the right and left hypogastric arteries and their continuation, the umbilical arteries—does not enter the pelvis, but, leaving the umbilical arteries at the navel, passes along the falciform ligament to the liver. After birth it is converted into a fibrous cord. (See Portal Vein, p. 685.)

The **superior gluteal veins** accompany the superior gluteal artery, and, passing through the upper part of the great sciatic foramen, open into the internal iliac vein near its termination, either separately or as a single trunk.

The **ilio-lumbar veins** open into the hypogastric a little higher than the superior gluteal. At times they join the common iliac vein.

The **lateral sacral veins** join the superior gluteal or the hypogastric at or about the same situation as the gluteal. They form with the middle sacral veins a plexus in front of the sacrum, and receive branches from the sacral canal.

The **obturator vein,** which lies below the obturator artery as it crosses the side of the pelvis, opens into the front of the hypogastric vein a little below the superior gluteal. Its branches correspond to those of the artery.

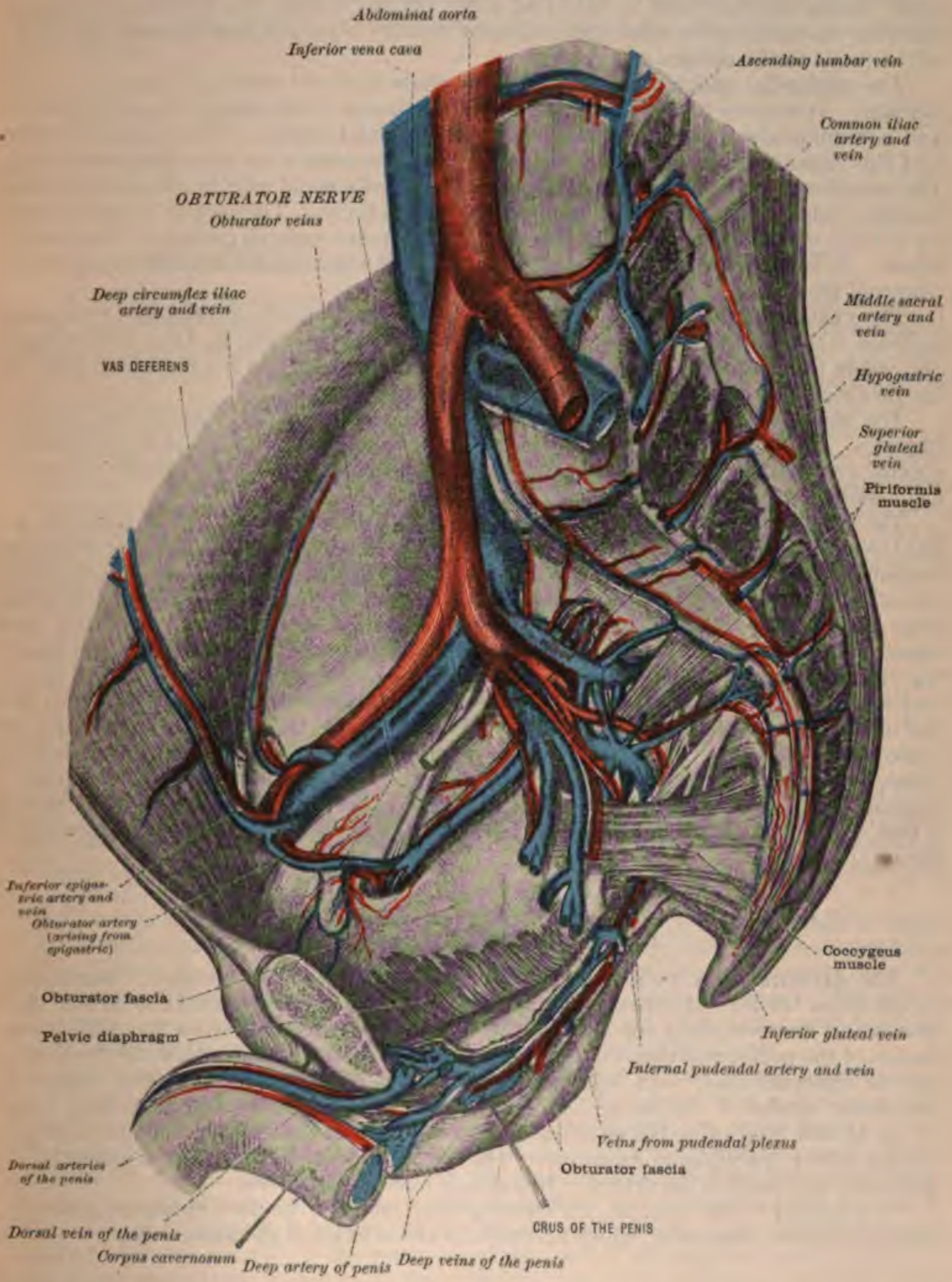
The **inferior gluteal (sciatic) veins** accompany the inferior gluteal (sciatic) artery, and, as a rule, unite to form a single trunk before joining the hypogastric a little below the obturator vein.

All the above veins so closely follow the ramifications of their respective arteries that no further special description of them is required. They all contain valves.

The **pudic vein** does not begin as the dorsal vein of the penis, but issues from the corpus cavernosum with the artery of that body. It communicates, however, with the dorsal vein before the latter pierces the uro-genital trigone. In the rest of its course it runs with the pudic artery, receiving tributaries corresponding to the branches of that vessel. It terminates in the lower part of the hypogastric (internal iliac) vein.

The **dorsal vein of the penis** begins in a plexus around the corona glandis, then runs along the centre of the dorsum of the penis between the two pudic arteries.

FIG. 500.—THE VEINS OF THE PELVIS, MALE. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Abdominal aorta
Inferior vena cava
Ascending lumbar vein
Common iliac artery and vein
OBTURATOR NERVE
Obturator veins
Deep circumflex iliac artery and vein
Middle sacral artery and vein
VAS DEFERENS
Hypogastric vein
Superior gluteal vein
Piriformis muscle
Inferior epigastric artery and vein
Obturator artery (arising from epigastric)
Coccygeus muscle
Obturator fascia
Pelvic diaphragm
Inferior gluteal vein
Internal pudendal artery and vein
Veins from pudendal plexus
Dorsal arteries of the penis
Obturator fascia
CRUS OF THE PENIS
Dorsal vein of the penis
Corpus cavernosum
Deep artery of penis
Deep veins of the penis

In this course it receives large tributaries from the interior of the organ, which, emerging for the most part between the corpus spongiosum and corpus cavernosum, wind obliquely over the outer surface of the latter structure to the dorsum of the penis to end in the dorsal vein. At the root of the penis the dorsal vein leaves the dorsal arteries, and, passing straight backwards between the two layers of the fundiform (suspensory) ligament, and then through either the subpubic ligament or the upper part of the fascia of the urogenital trigone (fig. 505), bifurcates, each branch passing backwards and downwards to the pudendal plexus of veins. At times the dorsal vein begins as two branches, which run between the dorsal arteries and only unite to form a single trunk about 3·7 cm. (1½ in.) from the trigone. Before passing through the trigone, it communicates on each side with the primary radicals of the pudic vein. After dividing into a right and a left branch within the pelvis, each vessel generally communicates with the obturator vein by a branch passing over the back of the pubis to the obturator foramen.

The **pudendal plexus** surrounds the prostate and the neck and fundus of the bladder. It receives in front the right and left divisions of the dorsal vein of the penis, and communicates posteriorly with the hæmorrhoidal plexus. The prostatic veins and the vesical plexus open into it, and it also communicates with the pudic vein. The veins forming the plexus are of large size, especially in old men, in whom they often become varicose, and contain phleboliths, or vein-stones. The plexus is surrounded by a kind of capsule formed by the endopelvic (recto-vesical) portion of the pelvic fascia. It terminates in a single stem on each side which opens into the hypogastric (internal iliac) vein.

The **vesical plexus** surrounds the apex, the sides, and the anterior and posterior surfaces of the bladder. It is situated between the muscular coat and the peritoneum, and where the bladder is uncovered by peritoneum external to the muscular coat in the pelvic cellular tissue. It opens into the pudendal plexus.

The **utero-vaginal** plexus connects with the hæmorrhoidal, vesical, and uterine plexuses. Its lower part drains through the internal pudic veins and the pudendal plexus, and its upper portion largely through the ovarian veins, and partly through the uterine veins to the hypogastric (fig. 493).

The **hæmorrhoidal plexus of veins** surrounds the rectum, and is situated at the lower part of that tube. It consists of two portions, one of which, the internal hæmorrhoidal plexus, is situated between the muscular and mucous coats, while the other, the external hæmorrhoidal plexus, rests upon the outer surface of the muscular coat. The veins of this latter plexus terminate in the inferior, middle, and superior hæmorrhoidal veins. The **inferior** join the pudic; the **middle** accompany the middle hæmorrhoidal arteries, and open into the hypogastric (internal iliac) and superior hæmorrhoidal veins; the **superior** form the commencement of the inferior mesenteric vein, and through this the blood gains the portal vein. None of these veins have any valves, hence the enlargement of the inferior hæmorrhoidal veins, a condition known as piles, when the portal vein is obstructed, as from compression of its capillaries in cirrhosis of the liver. Through the hæmorrhoidal veins a free communication is established between the systemic and portal system of veins.

THE EXTERNAL ILIAC VEIN

The **external iliac vein** is the upward continuation of the femoral. Beginning at the lower border of Poupart's ligament, it accompanies the external iliac artery upwards and inwards along the brim of the true pelvis, lying at first on the horizontal ramus of the pubis, and then on the psoas muscle. It terminates by joining the hypogastric (internal iliac) vein behind the hypogastric (internal iliac) artery, opposite the lower border of the sacro-iliac synchondrosis, to form the common iliac vein. It lies at first internal to the external iliac artery, and on the left side remains internal to the artery throughout its course. On the right side, however, as it ascends, it gradually gets behind the artery. It contains one or two valves.

In addition to the femoral, the external iliac receives the deep epigastric and the deep circumflex iliac veins, which accompany the arteries of the same name.

THE SUPERFICIAL VEINS OF THE ABDOMINAL WALL

The plexus of superficial veins of the anterior abdominal wall is continuous with that of the thorax (fig. 471). Its main channels are the superficial circumflex iliac, the superficial epigastric, and the external pudic, all of which open into the femoral below Poupart's ligament. The superficial epigastric connects freely with the superficial plexus of veins formed by the perforating branches of the internal mammary vein, and a branch of the superficial circumflex iliac may unite directly with a descending branch from the lateral thoracic to form a stem, the **thoraco-epigastric** vein, extending from the femoral to the axillary veins, and thus making a superficial anastomosis between the systems of the inferior and superior venæ cavæ.

The superficial veins of the lumbar region form an abundant plexus which drains through the dorsal and lateral perforating branches of the intercostal, lumbar, and sacral veins.

THE VEINS OF THE LOWER EXTREMITY

The **veins of the lower extremity** are divided into the superficial and the deep. The **superficial veins** lie in the subcutaneous tissue superficial to the deep fascia, through which they receive numerous communicating branches from the deep veins. They are collected chiefly into two main trunks, which, beginning on the foot, extend upwards, one, the great saphenous, lying antero-internally, and the other, the lesser saphenous, postero-externally. The former finally joins the femoral vein by passing through the deep fascia at the groin; the latter the popliteal by perforating the fascia at the ham. The **deep veins,** on the other hand, accompany their corresponding arteries. Below the knee there are two veins to each artery; above it, excepting at the back of the thigh, there is only one vein to each artery. All the veins of the lower limb have valves which are more numerous than in the veins of the upper extremity and in the deep than in the superficial veins.

I. THE SUPERFICIAL VEINS OF THE LOWER EXTREMITY

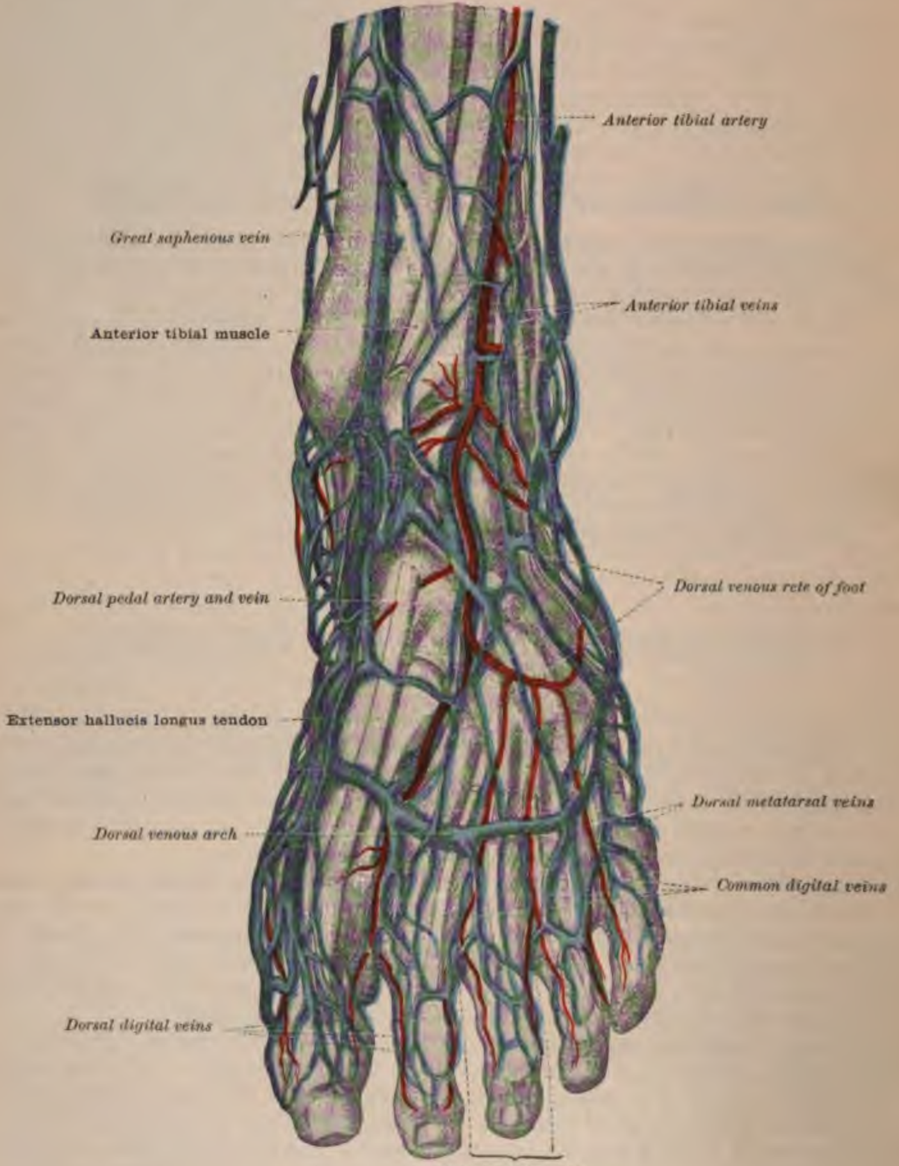
The superficial veins of the lower limb begin in the plexuses of the foot. The **plantar digital veins** open into arches situated at the base of the toes, and these arches are connected with a **plantar cutaneous plexus** of veins which drain partly into the deep veins of the sole and partly into the medial and lateral marginal veins situated on the borders of the foot. The median marginal vein passes to the great saphenous, while the lateral marginal enters the lesser saphenous.

The superficial veins of the dorsum of the foot begin in the **dorsal digital veins,** which make small arches at the bases of the toes. From these arches one or more vessels pass to a large **dorsal cutaneous arch,** which connects with both the medial and lateral marginal veins and so with the saphenous veins. The arch is likewise connected with the venous plexus over the ankle. The dorsal veins have also wide anastomoses with the veins that follow the anterior tibial artery.

The **great** or **internal saphenous vein** commences as the medial marginal vein on the inner side of the foot at the inner end of the dorsal venous arch, and, after receiving branches from the sole which join it by turning over the inner border of the foot, passes upwards in front of the inner malleolus, and then obliquely upwards and backwards about a finger's breadth from the posterior border of the tibia in company with the saphenous nerve, which becomes superficial just below the knee. Continuing its course upwards, it passes behind the internal condyle, and then runs upwards and somewhat outwards on the inner side of the front of the thigh to about 3·7 cm. (1½ in.) below Poupart's ligament, where, after receiving the superficial circumflex iliac, superficial epigastric, and superficial external pudic veins, it dips through the fossa ovalis (saphenous opening) in the fascia lata, and ends in the femoral vein. In its course up the leg and thigh it receives numerous unnamed cutaneous branches, and at variable intervals communicates with the deep veins. Just before it passes through the saphenous opening it often receives a large vein formed by the union of several of the cutaneous veins on the upper and outer part of the thigh, and a second vein, the **accessory saphenous,** formed by the union of the cutaneous veins from the inner and back part of the thigh (fig. 503). The great saphenous vein contains from ten to twenty valves.

The **lesser** or **external saphenous vein** begins in the lateral marginal vein at the outer end of the venous arch on the dorsum of the foot. After receiving branches from the sole, which turn over the outer border of the foot, it passes behind the outer malleolus, and then upwards and inwards, lying at first along the outer side of the tendo Achillis, afterwards along the back of the calf, in company with the sural (short saphenous) nerve, to about the lower part of the centre of the popliteal space, where it perforates the deep fascia, and, sinking between the two heads of the gastroc-

FIG. 501.—THE VEINS OF THE DORSUM OF THE FOOT. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Anterior tibial artery
Great saphenous vein
Anterior tibial veins
Anterior tibial muscle
Dorsal venous rete of foot
Dorsal pedal artery and vein
Extensor hallucis longus tendon
Dorsal metatarsal veins
Dorsal venous arch
Common digital veins
Dorsal digital veins
Intercapitular veins

nemius, opens into the popliteal vein. As it passes up the calf between the superficial and deep fascia, it receives numerous cutaneous veins from the heel, and the outer side and back part of the leg, and communicates at intervals, through transverse or intermuscular branches, with the deep veins (venæ comites) accompanying the peroneal artery. Just before perforating the deep fascia, it receives a large descending branch from the lower and back part of the thigh, and sends upwards and inwards a communicating vein to the long saphenous. A small offshoot from the inferior sural branch of the popliteal artery accompanies the vein for a short distance down the back of the calf. The lesser saphenous vein contains from nine to twelve valves.

FIG. 502.—THE VEINS OF THE SOLE OF THE FOOT. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

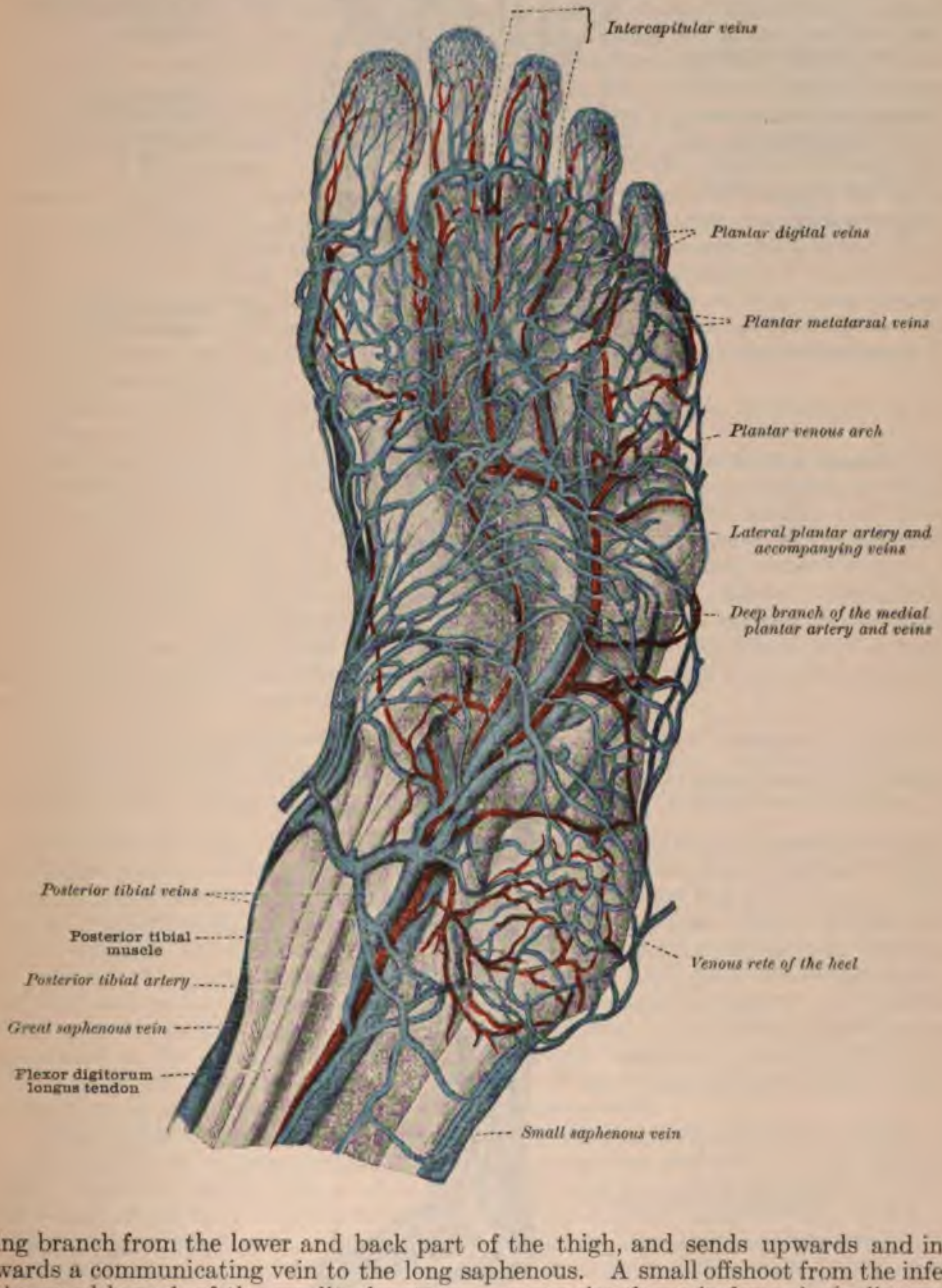
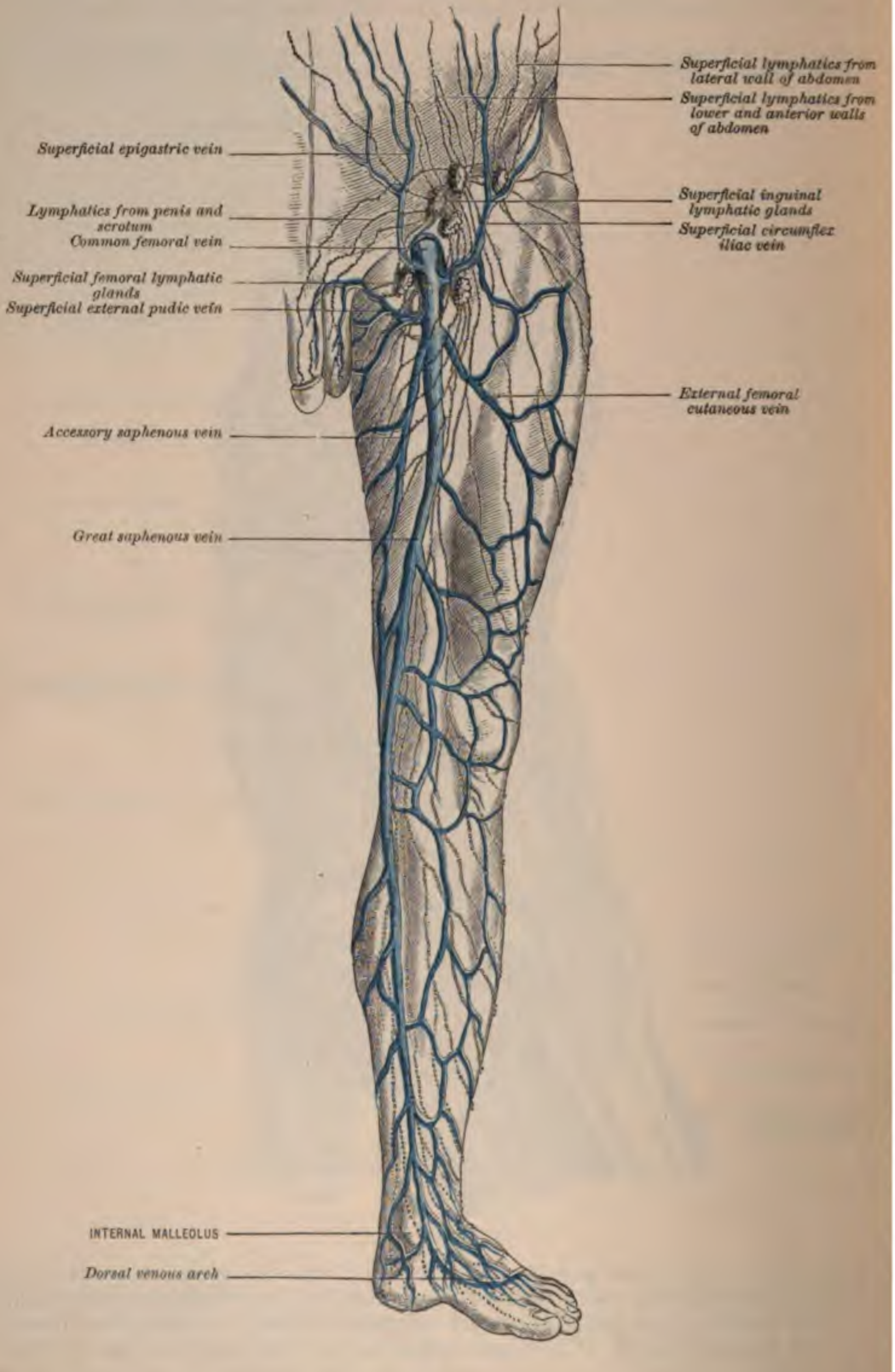

Intercapitular veins
Plantar digital veins
Plantar metatarsal veins
Plantar venous arch
Lateral plantar artery and accompanying veins
Deep branch of the medial plantar artery and veins
Posterior tibial veins
Posterior tibial muscle
Posterior tibial artery
Great saphenous vein
Flexor digitorum longus tendon
Venous rete of the heel
Small saphenous vein

FIG. 503.—THE SUPERFICIAL VEINS AND LYMPHATICS OF THE LEFT LOWER LIMB. (Walsham.)


Superficial lymphatics from lateral wall of abdomen
Superficial lymphatics from lower and anterior walls of abdomen
Superficial epigastric vein
Superficial inguinal lymphatic glands
Lymphatics from penis and scrotum
Superficial circumflex iliac vein
Common femoral vein
Superficial femoral lymphatic glands
Superficial external pudic vein
External femoral cutaneous vein
Accessory saphenous vein
Great saphenous vein
INTERNAL MALLEOLUS
Dorsal venous arch

II. THE DEEP VEINS OF THE LOWER EXTREMITY

The **deep veins of the lower extremity** accompany the arteries, and have received corresponding names. From the foot to the knee there are two veins to each artery. These veins run on either side of the corresponding artery, and communicate at frequent intervals with each other across it. They are known as the venæ comites. From the knee upwards there is a single vein to each artery, except at the back of the thigh and in the gluteal region, where there are commonly two.

The veins of the foot and leg.—The venæ comites of the internal and external plantar arteries, after receiving small veins corresponding to the branches of these vessels, unite beneath the abductor hallucis muscle to form the venæ comites of the posterior tibial artery. These, again, receive, at the spot where the peroneal artery is given off from the posterior tibial, the venæ comites of the peroneal artery, which are formed in like manner by the confluence of the various veins corresponding to the branches of that vessel. Opposite the lower border of the popliteus muscle, the posterior tibial veins unite with the anterior tibial veins, which pass through the upper part of the interosseous membrane with the anterior tibial artery, to form the popliteal. The anterior tibial veins are the continuations of the venæ comites of the dorsal artery of the foot, which, in their turn, are formed by the confluence of the veins accompanying its various branches. The anterior tibial venæ comites thus formed run with the anterior tibial artery up the front of the leg, and, after passing through the interosseous membrane along with the artery, join the posterior tibial veins to form a single popliteal.

All these veins contain numerous valves, and communicate, by means of intermuscular branches, with the superficial veins.

The **popliteal vein** is formed by the confluence of the venæ comites of the anterior and posterior tibial arteries at the lower border of the popliteus, and extends upwards to the opening in the adductor magnus at the junction of the middle and lower third of the thigh, where it changes its name to femoral. It accompanies the popliteal artery, lying superficial to it in the whole of its course, and tightly bound down to it by its fascial sheath. At the lower part of the space it is a little internal to the artery, but, crossing the vessel obliquely as it ascends, lies a little external to it at the upper part of the space. The tibial (internal popliteal) nerve lies superficial to the vein, being external to it above, then on it, and then a little to its inner side. The popliteal vein contains two or three valves.

The **chief variations of the popliteal** are:—(1) It may lie between the artery and the bone. (2) It may be double through a part or the whole of the popliteal space. (3) Two veins by frequently uniting in front and behind the artery may form a kind of plexus around the vessel. (4) It may be shorter than usual in consequence of a high union of the tibial venæ comites.

The **femoral vein,** the continuation of the popliteal upwards, extends from the tendinous opening in the adductor magnus to 3·7 cm. (1½ in.) below Poupart's ligament, where it joins the profunda vein to form the common femoral vein. In this course its relations are similar to those of the superficial femoral artery. As the vein passes through the adductor canal, it lies behind and a little external to the artery. At the apex of the femoral trigone (Scarpa's triangle) it is still posterior to the artery, but gradually passes to the inner side as it ascends through the trigone. It contains three pairs of valves. The close connection of the vein to the artery should be remembered in the operation of ligature. The sheath should be opened on its inner side, that is, well over the artery, and the point of the aneurysm needle kept closely applied to the artery lest it perforate the overlapping vein.

Tributaries.—The venæ comites corresponding to the branches of the femoral.

The **profunda** or **deep femoral vein** accompanies the profunda or deep femoral artery, and receives the venæ comites corresponding to its various branches. Unlike the other veins of the lower extremity, it lies in front of its companion artery, and is at first a little internal to it. It terminates by joining the superficial femoral vein about 3·7 cm. (1½ in.) below Poupart's ligament in the angle between the femoral and profunda arteries. It contains five valves.

The **common femoral vein** is a short thick trunk corresponding to the common femoral artery. It is formed by the confluence of the superficial femoral and profunda veins about 3·7 cm. (1½ in.) below Poupart's ligament, and is continued upwards to the lower border of that structure, where it takes the name of external iliac.

It lies on the same plane as the common femoral artery, but internal to that vessel, from which it is separated by a delicate prolongation of fascia stretching between the front and back layers of the femoral sheath. **Internally,** it is separated by a similar septum of fascia from the femoral canal. It usually contains two valves: one just above the junction with the profunda vein, the other just below Poupart's ligament (fig. 505).

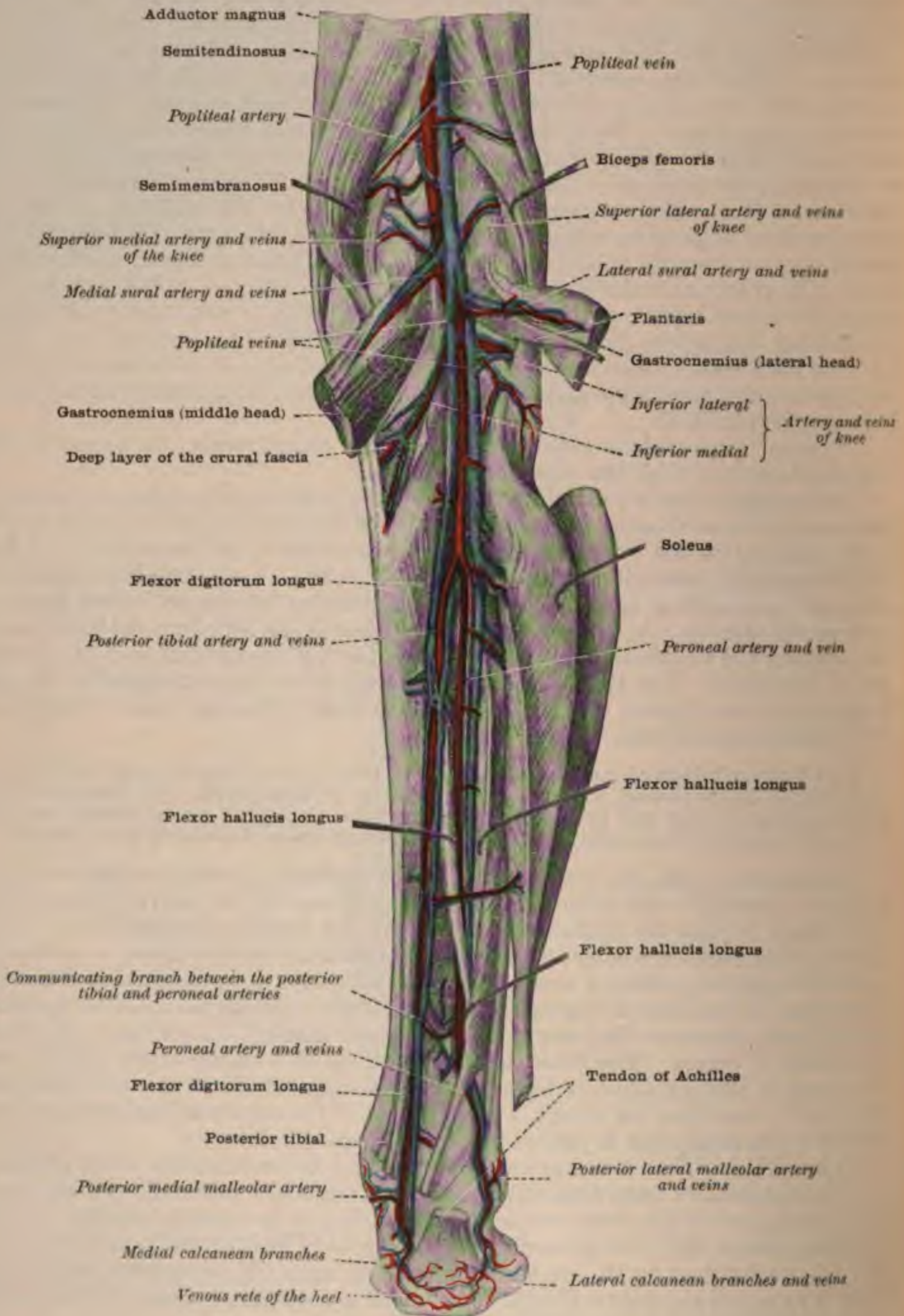


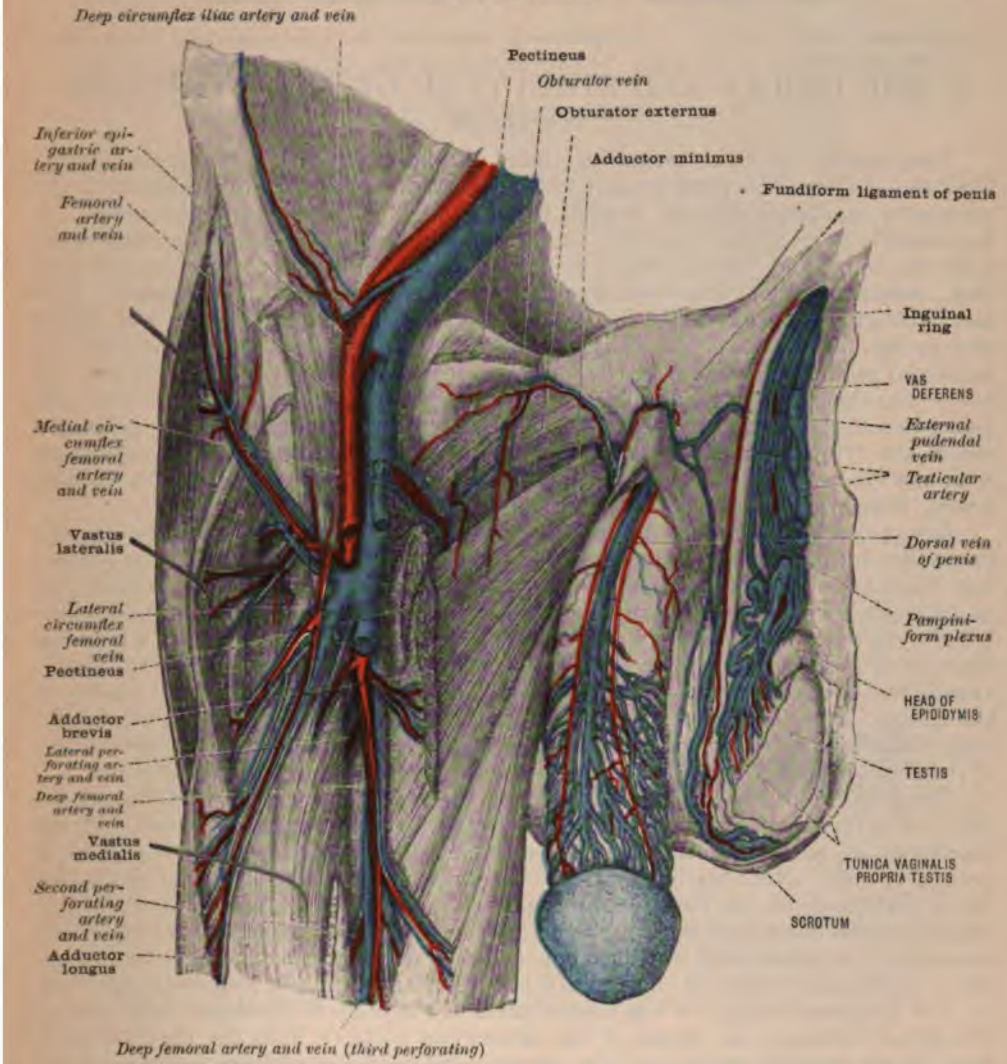
Fig. 504.—The Deep Veins of the Leg. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

Adductor magnus
Semitendinosus
Popliteal vein
Popliteal artery
Biceps femoris
Semimembranosus
Superior lateral artery and veins of knee
Superior medial artery and veins of the knee
Lateral sural artery and veins
Medial sural artery and veins
Plantaris
Popliteal veins
Gastrocnemius (lateral head)
Inferior lateral
Artery and veins of knee
Gastrocnemius (middle head)
Inferior medial
Deep layer of the crural fascia
Soleus
Flexor digitorum longus
Posterior tibial artery and veins
Peroneal artery and vein
Flexor hallucis longus
Flexor hallucis longus
Flexor hallucis longus
Communicating branch between the posterior tibial and peroneal arteries
Peroneal artery and veins
Flexor digitorum longus
Tendon of Achilles
Posterior tibial
Posterior lateral malleolar artery and veins
Posterior medial malleolar artery
Medial calcanean branches
Lateral calcanean branches and veins
Venous rete of the heel

Tributary.—The great saphenous vein which reaches it by passing through the fossa ovalis (saphenous opening) in the deep fascia.

Chief variations.—(1) The femoral vein may be double in part or in the whole of its length. (2) It may split into two and embrace the femoral artery. (3) It may pass through the adductor magnus above the femoral artery and run separate from the artery until it joins the profunda vein to form the common femoral vein. (4) It may run with the sciatic nerve and pierce the adductor magnus at the level of the lesser trochanter. When this occurs the femoral artery is usually very small, and the inferior gluteal (sciatic) artery is the chief nutrient vessel of the thigh.

FIG. 505.—THE FEMORAL VEIN. (After Toldt, "Atlas of Human Anatomy," Rebman, London, and New York.)


Deep circumflex iliac artery and vein
Pectineus
Obturator vein
Obturator externus
Adductor minimus
Fundiform ligament of penis
Inferior epigastric artery and vein
Femoral artery and vein
Medial circumflex femoral artery and vein
Vastus lateralis
Lateral circumflex femoral vein
Pectineus
Adductor brevis
Lateral perforating artery and vein
Deep femoral artery and vein
Vastus medialis
Second perforating artery and vein
Adductor longus
Inguinal ring
VAS DEFERENS
External pudendal vein
Testicular artery
Dorsal vein of penis
Pampiniform plexus
HEAD OF EPIDIDYMIS
TESTIS
TUNICA VAGINALIS PROPRIA TESTIS
SCROTUM
Deep femoral artery and vein (third perforating)

The development of the veins of the leg.—As in the arm, the first vein to form is the **marginal,** which lies superficially on the fibular side of the leg. It extends upwards through the entire length of the thigh, and communicates above with one of the veins of the hypogastric system. Later, a second superficial vein developes on the tibial side and becomes the great saphenous, and deep veins accompanying the arteries also appear. The marginal vein then makes a connection with the popliteal vein, its lower portion becoming the lesser saphenous, while its upper portion becomes greatly reduced, being represented in the adult by a descending stem which joins the terminal portion of the lesser saphenous and by one of the branches of the inferior gluteal vein.

THE LYMPHATICS

ORIGINALLY WRITTEN BY WILLIAM J. WALSHAM, F.R.C.S. REWRITTEN BY

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I. THE ORIGIN AND STRUCTURE OF THE LYMPHATIC SYSTEM

Until recent years the prevailing theory of the origin of the lymphatic system has been that it arose from dilated tissue-spaces, which thus had a relation to the lymphatic capillaries different in kind from that which they held to the veins. It has recently been shown, however, that the lymphatic system arises as outgrowths from the veins, and that the ducts grow in length by a sprouting of their endothelium, similar to that which characterises the growth of the blood-vessels. This method of growth has been described by Langer, Ranvier, and MacCallum, and can be seen in figs. 506 and 510. The discovery that the lymphatic vessels arise from the veins and gradually spread over the body was made by a study of pig embryos. It was found that there were four places from which the lymphatics budded off from the veins, two in the neck and two below the kidney, corresponding to the points at which the lymphatics of the amphibia open into the veins; that, corresponding with the lymph hearts of the frog, the pig embryo had four rudimentary sacs or hearts, from which ducts spread over the body.

Absorption, which in the adult is the essential function of the lymphatics, was originally a function of the blood-vessels, and in early embryos, before the lymphatic system is developed, must be carried on by the veins. Only secondarily do the veins give up the function of absorption to the lymphatics, and, indeed, there are certain parts of the body which the lymphatics never invade and in which the function of absorption is retained by the veins throughout life. The first lymphatic vessels which develope grow out along the veins to the skin, and form a plexus in the deeper layers of the subcutaneous tissue. Later, following the blood-vessels, they form a more superficial plexus, and finally send capillaries into the center of the dermal papillæ, while the blood-vessels are arranged towards their periphery.

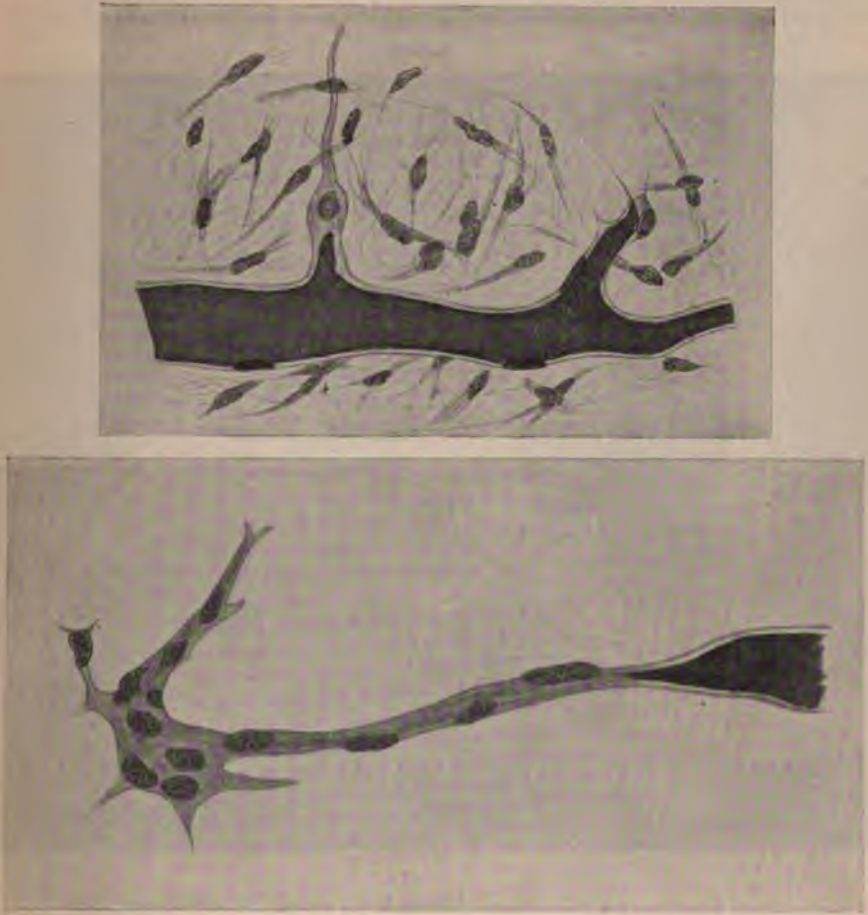
The invasion of the muscular system is by no means as complete as that of the skin. The lymphatics grow to the tendons, where they form rich plexuses, but the capillaries do not grow into the muscle tissue proper, where the blood-supply is peculiarly rich. Not that lymphatic ducts do not pass through muscle tissue, for the rich plexuses on the pleural and abdominal surfaces of the diaphragm, for example, are freely connected through the muscle, and the submucous and subserous plexuses of the alimentary canal are connected by ducts passing through the muscularis. But muscle tissue is, as a rule, destitute of any capillary lymphatic network.

The lymphatic supply of the deeper parts of the body is developed later, one or two stems following the course of the descending aorta to form the thoracic duct, from which branches extend to the viscera; and branches likewise accompany the arteries of the limbs throughout their course. In the case of the hollow viscera, such as the intestine, the branches typically form a primary plexus in the submucosa, from which vessels pass, on the one hand, to a subserous plexus, and, on the other hand, into the mucosa; in the solid organs there is also usually a superficial plexus, while additional vessels, sometimes abundant, as in the case of the liver and lungs, sometimes scanty, as in the kidneys, pass with the nutrient arteries or with some other supporting structure, such as the bronchi or the portal vein (fig. 507), into the deeper parts of the organs and terminate in interlobular plexuses. The relation of these terminal plexuses has not for the most part been worked out.

As already noted, there are certain regions of the body which the lymphatics never invade. Among these there may be especially mentioned the entire central nervous system, the eyeball, and the entire cavity of the orbit, and probably the internal ear, all of which are characterised by standing in relation to extensive tissue-spaces.

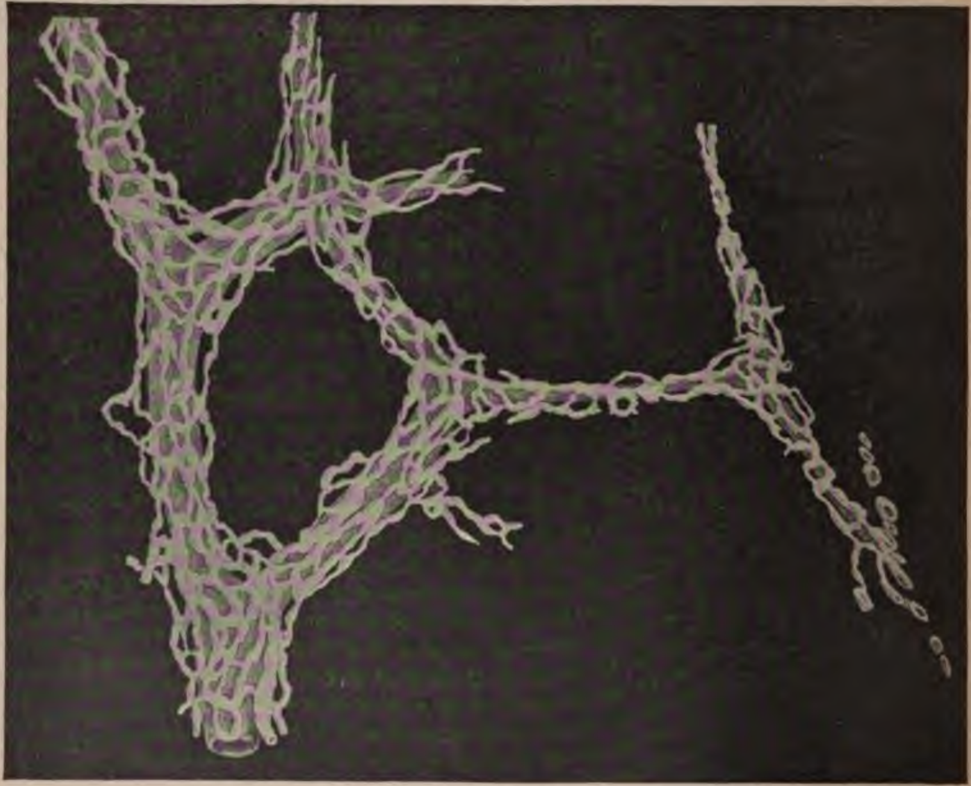
The Tissue-spaces or Lymph-spaces.—Our present theory of the lymphatic system throws considerable light on the relation of the lymphatics to the tissue-spaces. The lymphatic system can be sharply distinguished from the tissue-spaces, for we can define the lymphatics as a system of vessels with a definite lining of endothelium arising from the endothelium of the veins. The tissue-spaces are the spaces between the individual cells of any organ or those in the meshes of the connective-tissue fibres; they are filled with a fluid derived from the plasma of the blood. This fluid is commonly called **lymph,** and the spaces are often known as **lymph-spaces,** an unfortunate confusion of names, since anatomically the tissue-spaces are quite distinct from the lymphatics, and are no more a part of the lymphatic system than they are a part of the blood-vascular system. The tissue-spaces vary much in different parts of the body, both by reason of the differences in the tissues themselves, and by the varying fluid content of the spaces. In certain regions the areolar tissue is loose and the spaces consequently wide, as, for example, around the nervous system, while in contrast with this condition in the cartilaginous tissues the intercellular substance is so dense that fluid can filter through it only slowly.

FIG. 506.—THE SPROUTING OF LYMPHATIC CAPILLARIES IN THE PIG. (After MacCallum.) The lymphatics are injected and the sprouts are both single cells and clumps of cells.



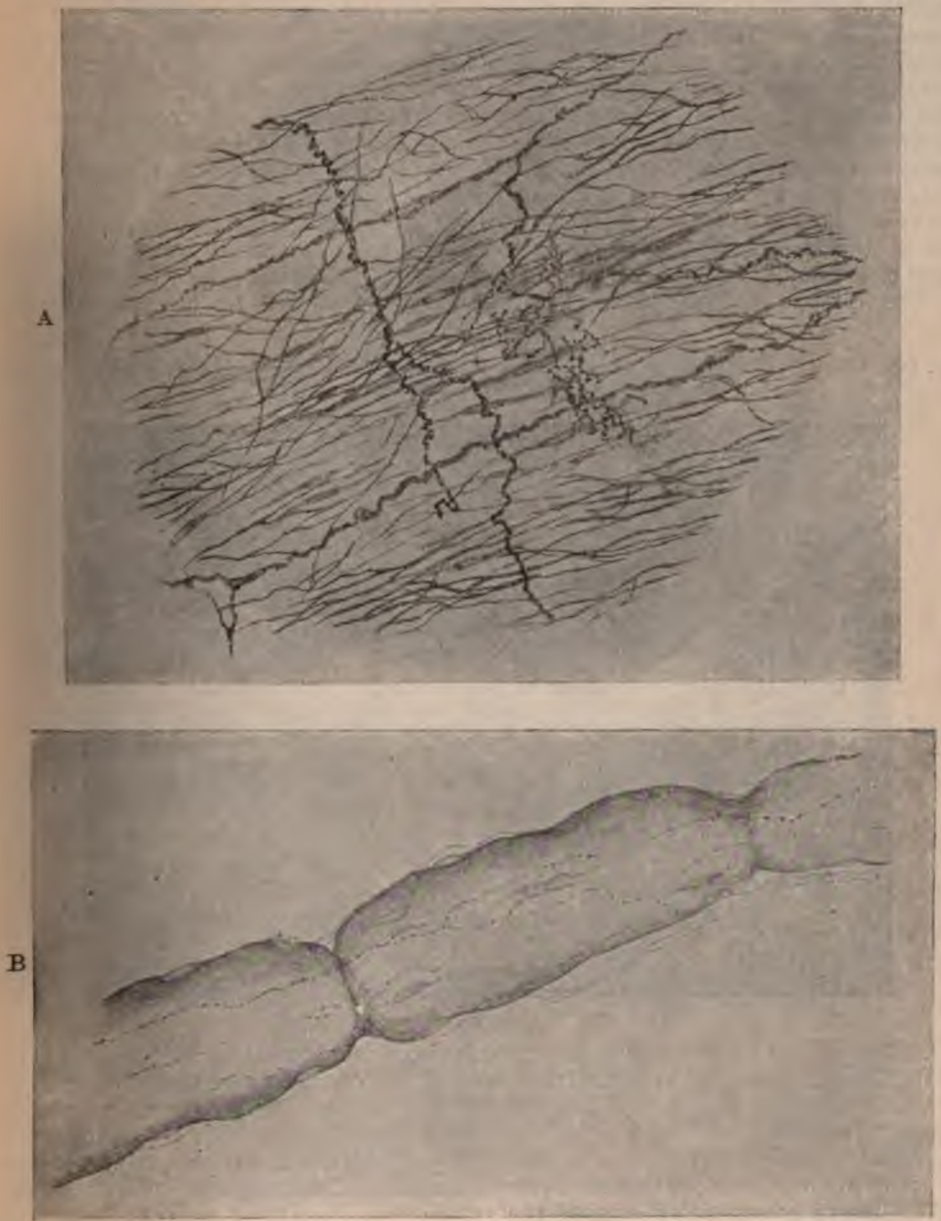
Von Recklinghausen believed, from the results obtained from silver impregnation of the tissues, that there were definite canals in the tissues which connected directly with the lymphatics. The question of open or closed lymphatics was first brought up by Lieberkühn, in connection with the vessels of the intestinal villi, and the question has been a burning one ever since. Inasmuch as the lymphatics are a part of the general vascular system, the question may first be considered in connection with that system as a whole. It is known that in almost all places the blood-vessels are closed, and yet not so completely that the wandering cells cannot push their way between the endothelium and wander into the tissue-spaces. In two places, however, namely, in the spleen and in the bone-marrow, there is evidence of an open circulation, there being a more than usually free passage for the corpuscles in and out of the vessels, thus making possible a rapid calling into the circulation of cells from the bone-marrow, for example, after bleeding an animal. In the blood-vascular system, therefore, the vessels vary in their relations to the tissue-spaces. In the lymphatic system there are likewise certain places where it is especially easy to demonstrate a close physiological relation between the tissue-spaces and the capillaries. Thus, in the liver, Mall has shown that granules injected into the artery are returned by the lymphatics as well as by the veins, and an interstitial injection into a muscle, where there are no lymphatics, will enter the lymphatics of the tendon. Other regions of easy absorption are found in the lymphatics of the diaphragm, which readily take up granules from the peritoneal cavity, and in the central chyle-vessels of the intestinal villi, which readily absorb globules of fat from the intestine. In other words, are there permanent or temporary openings in the walls of the lymphatic capillaries? The absorption of the fluid through the endothelium of the lymphatics is readily understood, but the question is: Do granules enter through preformed and permanent openings between the endothelial cells, or do the cells separate in various places to allow granules to enter?

FIG. 507.—LYMPHATIC PLEXUS AROUND THE PORTAL VEIN IN AN ADULT MAN. (After Teichmann.) Showing the supporting relation of the vein.



Still another region where ready communication takes place between the lymphatic vessels and the tissue-spaces is in the nose; an injection forced into the subdural spaces beneath the frontal lobes of the brain will enter the lymphatic capillaries of the nasal mucous membrane. MacCallum has shown that the lymphatic capillaries in the skin of the embryo are closed vessels, since by injecting under the microscope it can be seen that extravasations are accompanied by explosive ruptures of the walls of the vessels. These facts do not prove, however, that all lymphatics, such, for example, as those of the special regions already noted, are closed, and while it cannot be said that permanent openings in them have been satisfactorily demonstrated, yet it is certain that exceedingly free absorption may take place into them from the tissue-spaces.

FIG. 508.—A. THE ADVENTITIAL AND SUPRA-MUSCULAR NERVE PLEXUSES, TOGETHER WITH SENSORY ENDINGS IN THE THORACIC DUCT OF A DOG. (Methylene-blue method.) B. NERVE-FIBRES ON THE ENDOTHELIUM OF A LYMPHATIC CAPILLARY OF A DOG. (After Kytmanoff.)



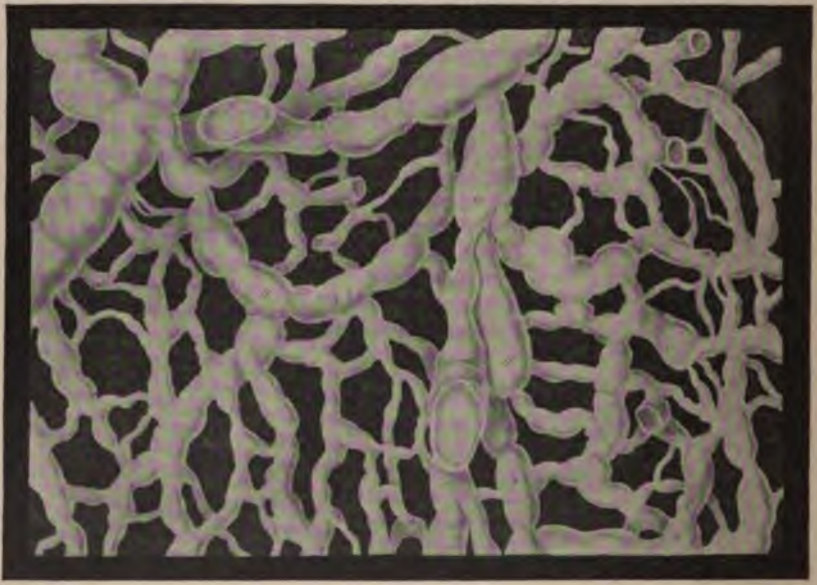
The question of absorption by the lymphatics will not be clear until something is known as to the action of their nerve-fibres upon the endothelium. Kytmanoff has shown that the nerves, which are for the most part non-medullated, are in four sets: first a plexus in the adventitia; second, a plexus which rests on the muscle layer; third, motor endings upon the individual muscle-cells; and, fourth, a plexus on the endothelium.

STRUCTURE OF THE LYMPHATIC DUCTS AND CAPILLARIES

In structure the lymphatic system is more like the venous than the arterial system, and yet there are certain well-marked differences between the veins and the lymphatic ducts, and between the lymphatic and vascular capillaries. In the vascular system, the branching of the vessels is dendritic; that is to say, where two branches unite, a larger vessel is formed, the arrangement of the veins being, however, less characteristically tree-like than that of the arteries, since the veins tend to form plexuses (fig. 471). The collecting lymphatic ducts, on the other hand, have a more uniform diameter throughout; they branch somewhat, but do not form rich plexuses (compare figs. 489 and 525). Like the veins, they are thin-walled, the thinness being due to a reduction of the muscle coat as compared with the arteries. Both the veins and the lymphatic ducts contain valves, but these are much more numerous in the lymphatics, and are very numerous in the small lymphatic ducts down as far as the terminal capillaries such as the central lacteals of the villi.

The lymphatic capillaries form characteristic plexuses, as is shown in fig. 509. The vessels are irregular in form, small channels frequently arising from dilated sacs. The contrast between this and the plexus of uniform blood-capillaries is very characteristic, and is well brought out in fig. 510, which shows a lymphatic capillary beside a blood-capillary. The lymphatic is many times the diameter of the blood-capillary, and shows the irregularity of shape and the presence of valves which occur at the dilatations. From the sides of the lymphatic vessels blind, sprout-like processes are of frequent occurrence.

FIG. 509.—THE LYMPHATICS FROM THE SCROTUM. (After Teichmann.) Showing the transition of the capillaries to the ducts with valves (*a*, *a*, *a*).

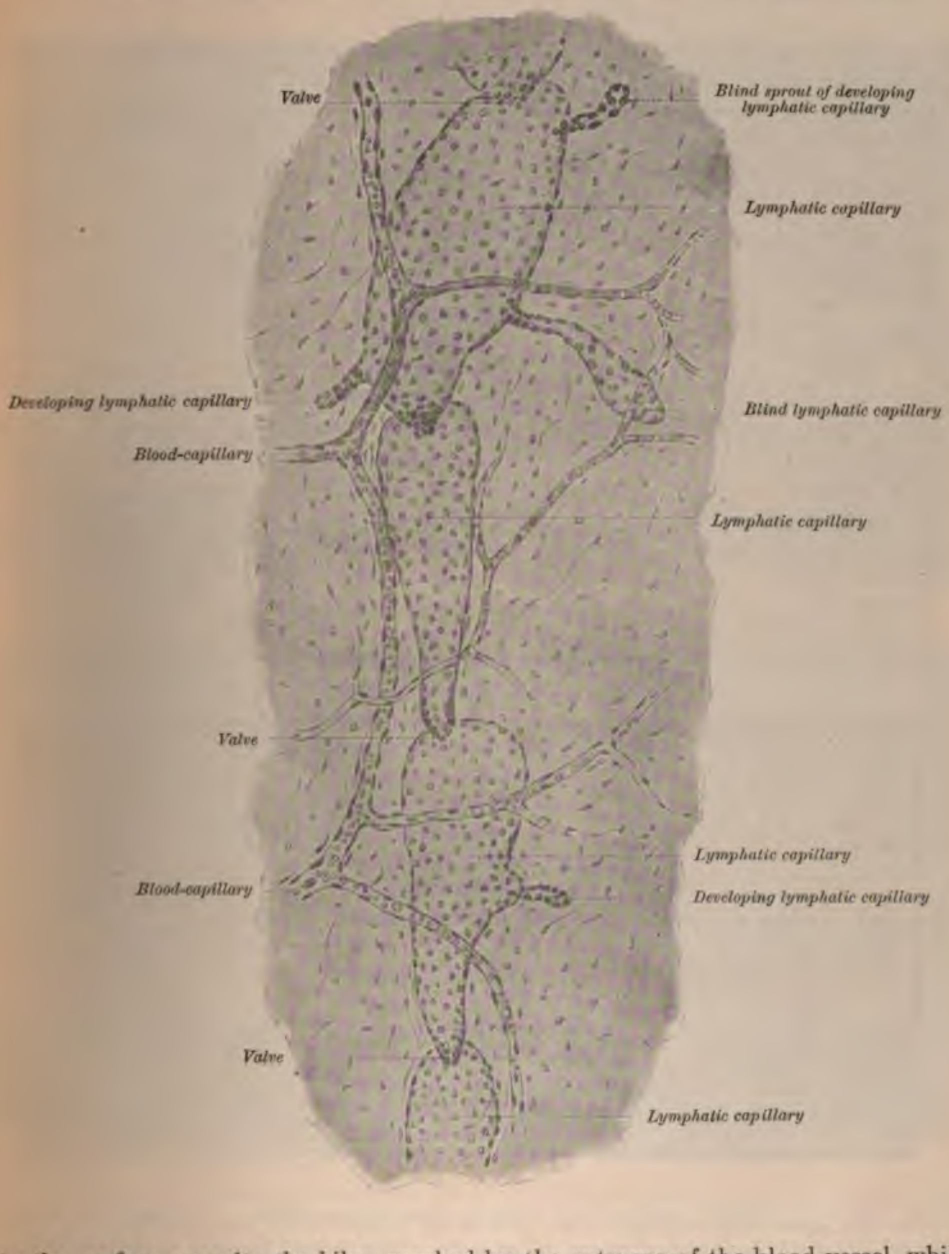


Finally, in the course of the lymphatic vessels, there are interposed the so-called **lymph-nodes** (lymphoglandulæ), which are unrepresented in the blood-vascular system, unless the hæmal nodes have a similar relation to the veins.

The Lymph-nodes.—The lymph-nodes vary all the way from single follicles, microscopic in size, up to compound nodes the size of an olive or larger. In colour they vary according to position and state of function. The bronchial nodes, for example, being infiltrated with carbon, are black; the mesenteric nodes become milk white during digestion, and other nodes become more translucent when their sinuses are filled with fluid.

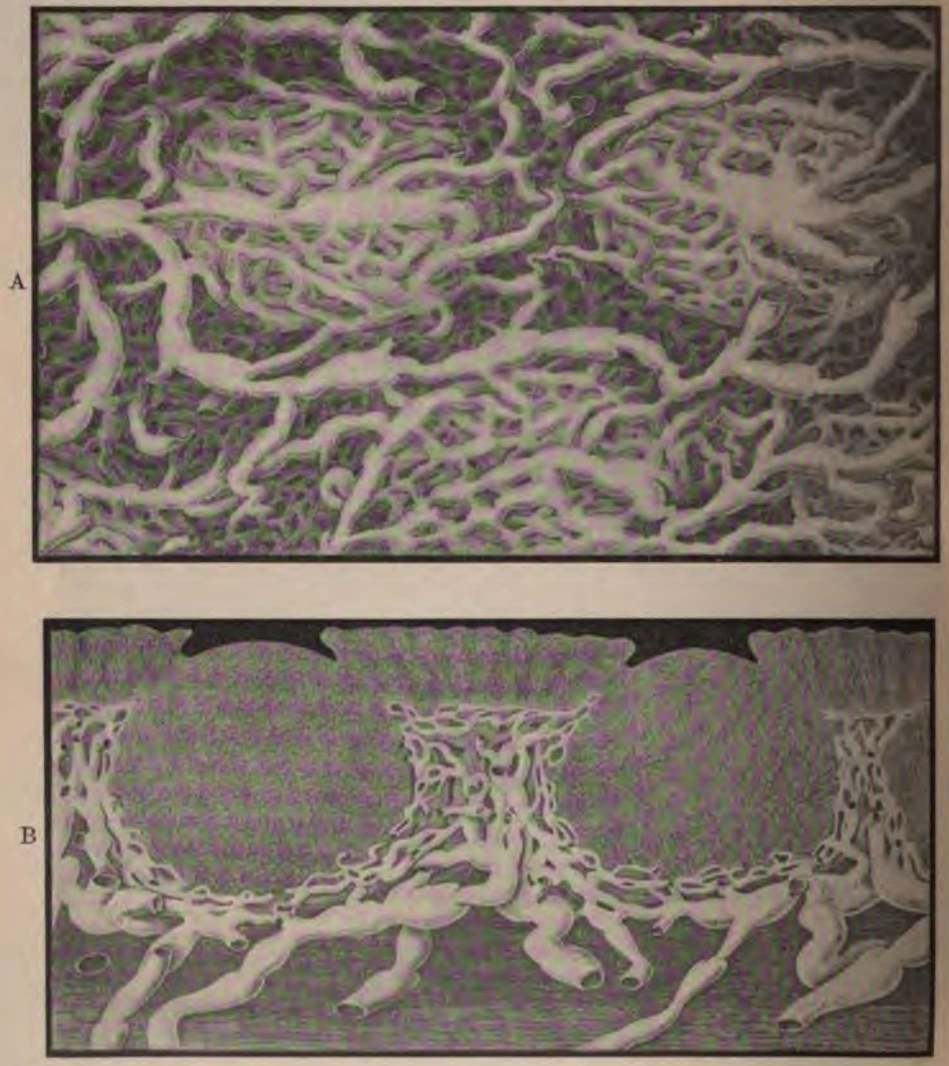
A single follicle consists of an artery surrounded by a mass of connective-tissue reticulum, the meshes of which are filled with lymphocytes (fig. 511). Enclosing this structure is a rich plexus of lymphatic vessels, the afferent ducts of which come to the surface opposite the hilus, marked by the entrance of the blood-vessel, while the efferent ducts emerge at the hilus. The peripheral plexus of lymphatic capillaries is so abundant that it forms a so-called sinus. Such a follicle may be surrounded by a connective-tissue capsule, and from this capsule reticulum fibrils run in between the ducts of the peripheral sinus to join the reticulum core of the follicle. Thus if all the cells were washed out a framework of reticulum would

FIG. 510.—DEVELOPING LYMPHATIC AND BLOOD-CAPILLARIES. (After Ranvier.)


Valve
Blind sprout of developing lymphatic capillary
Lymphatic capillary
Developing lymphatic capillary
Blind lymphatic capillary
Blood-capillary
Lymphatic capillary
Valve
Lymphatic capillary
Blood-capillary
Developing lymphatic capillary
Valve
Lymphatic capillary

be left, dense in the centre and open at the periphery. In a compound node the follicle is the unit of structure, and between the follicles bands of connective tissue known as trabeculæ, run in from the capsule. The **medullary cords** are formed by cells which border the artery, while the **follicles** are clumps of cells around capillaries, and it is in these that division of the lymphocytes takes place. In the spaces between the vessels of the vascular tree, the lymphatic sinuses of the node are found. This is beautifully shown in two figures from Teichmann. The first one shows that the peripheral sinus is made of a most abundant plexus of lymph-ducts, while the second shows that the central sinuses have a similar structure (fig. 512).

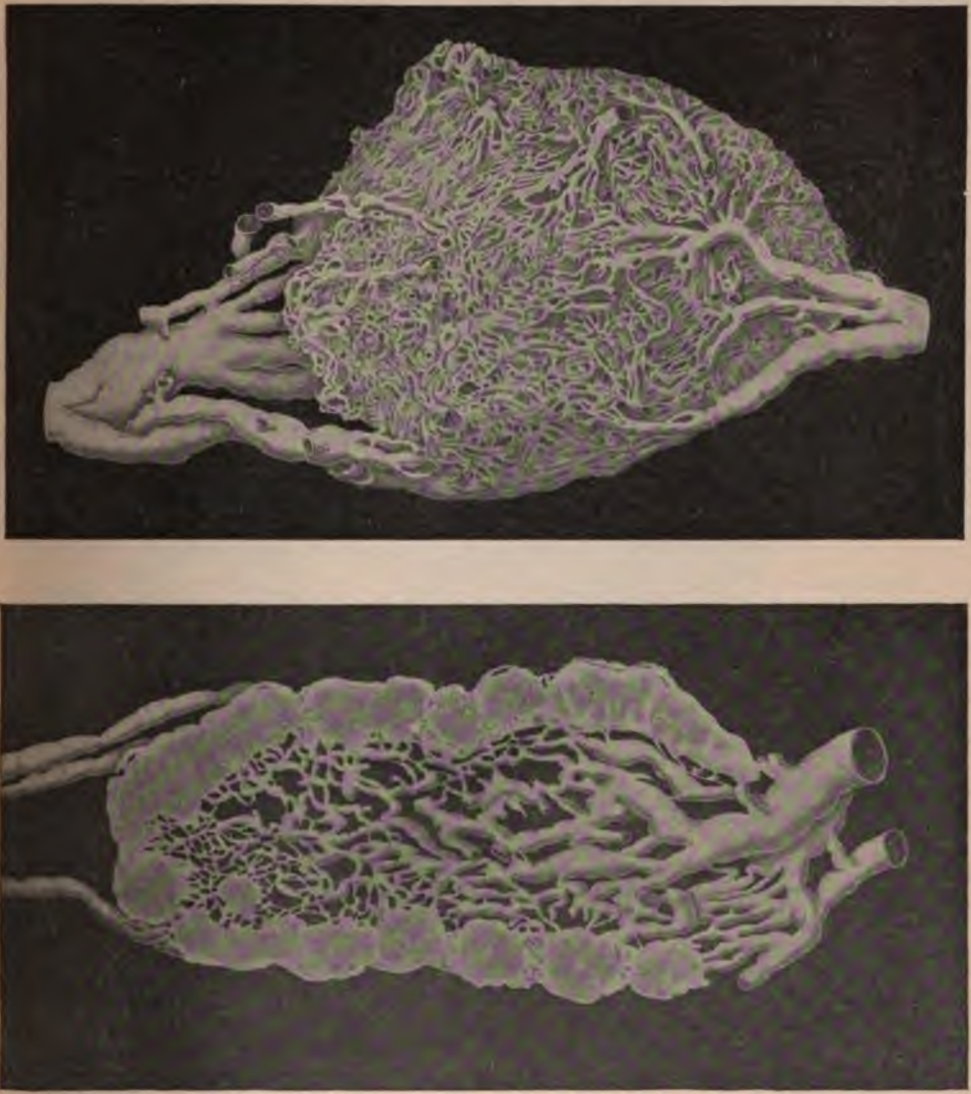
FIG. 511.—SURFACE VIEW AND SECTION OF LYMPH-NODES OF THE INTESTINE. A. Solitary follicle. B. Peyer's patch. (After Teichmann.)



In the mammalian embryos the system of lymph-ducts and capillaries is well formed before lymph-nodes begin to appear. The nodes possess a double function:—(1) being intercalated in the lymph current, they modify the composition of the lymph, and act also as mechanical filters; (2) they are the places where multiplication of the lymphocytes occurs.

As regards the **distribution** of lymph-nodes, it may be said that throughout the subcutaneous capillary network they are absent or, at all events, of rare occurrence; they do occur, however, in the course of the larger collecting ducts which drain the network. In the mucous membranes, on the other hand, nodes are of frequent occurrence in the capillary zone, being represented by the follicles of the tonsils, the lingual and pharyngeal tonsils, as well as by the numerous solitary and compound follicles of the intestine (fig. 511). In two instances the lymph-nodes of mucous membranes come so near the surface that the lymphocytes actually pass between the epithelial cells, as has been shown in the tonsil by Stöhr. In sections of the lung of the adult pig it may be seen that lymph-nodes in the walls of the bronchi are often so close to the surface that the lymphocytes invade the simple epithelial layer.

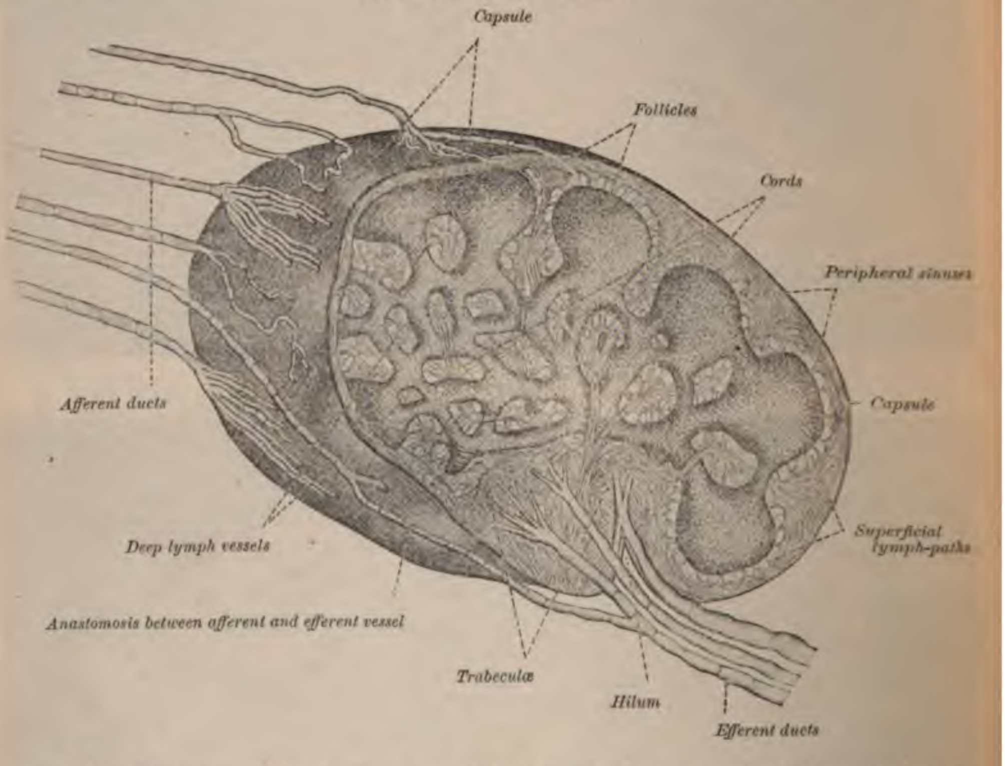
FIG. 512.—SURFACE VIEW AND SECTION OF A LYMPH-NODE SHOWING THE PERIPHERAL AND CENTRAL SINUSES. (After Teichmann.)



The different organs of the body vary considerably as regards the presence of the small lymph-nodes in the capillary areas. As has been stated, throughout the alimentary canal they are numerous, and likewise in the lung; but in the kidney, if they occur, they are rare. On the other hand, they are common in the liver. Some of these minute nodes show no sinus distinct enough to be made out in uninjected preparations, and it is a question whether some of them may not be merely heaps of lymphocytes around an artery, that is to say, merely patches of lymphoid tissue.

A second point worthy of note is that in almost all instances the lymph must pass through a chain of nodes before reaching the veins. For example, practically all the lymph from the arm must pass through nodes of the axillary group, some of it in addition passing through the nodes of the elbow. In the case of the intestine, it comes into relation, first, with the submucosal nodes; second, with a series in the mesentery near the wall of the intestine; third, with nodes situated in the root of the mesentery; and fourth, with the præaortic nodes. In considering these different sets of nodes three different groups may be distinguished:—First, **regional nodes,** placed at points from which ducts radiate out to drain large or small areas; their drainage areas vary greatly in extent, the supra-clavicular group, for example, draining the head, neck, arm (in part), and chest-wall, the axillary group draining the arm and chest-wall, while the group situated at the elbow receives only a portion of the drainage of the forearm and hand (fig. 525). Second, the **intercalated nodes,** which are nodes intercalated in the course of a lymph-duct. They are nearer the capillary zone than the regional nodes, and may consist of but a single follicle, which has, as it were, invaginated the wall of a lymph-duct, so that the lumen of the duct forms the peripheral sinus. They drain only a limited capillary zone. The third type consists of the **follicles** which are within the capillary zone, and are represented by the solitary follicles and Peyer's patches of the intestine (fig. 511).

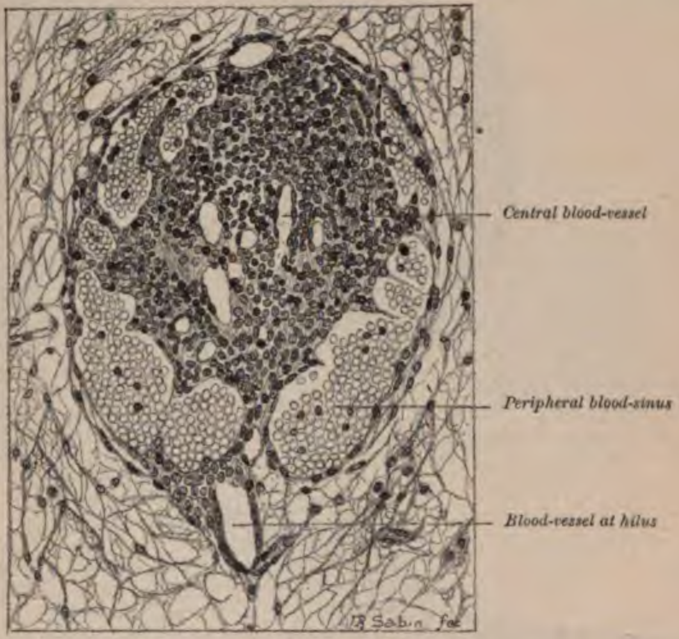
FIG. 513.—DIAGRAM OF A LYMPH-NODE. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)



The hæmolymph nodes.—In addition to the ordinary lymph-nodes, there occur along the course of certain veins small nodes which are either red or brown in color, according to their state of functional activity. These are the **hæmolymph nodes.** The red nodes closely resemble in structure an ordinary lymph-node, except that the sinuses are filled with blood, while the brown nodes show not blood, but blood pigment, both free in the sinuses and in the phagocytic cells of the sinuses. In certain respects these hæmal nodes resemble the spleen, there being a reduction of the medullary cords and an increase in the amount of the sinuses, which resemble those of the spleen-pulp rather than the more open lymphatic sinuses and their trabeculæ are also like those of the spleen in having smooth muscle-cells, which are very few in the lymphatic nodes. Some of these hæmal nodes have lymphatic ducts, but whether, as in the spleen, these ducts are limited to the capsule, or whether they open into the blood-sinuses, making true hæmolymph nodes, is not yet clear.

The difficult point in connection with the structure of the hæmolymph nodes is the relation of the blood-sinuses to the blood-vessels. The greater weight of evidence seems to favour the view that the sinuses are connected with the veins rather than that the arteries open directly into them. This point may be cleared up by a study of their development. For example, in fig. 514 is shown a hæmolymph node in the neck of a pig—24·5 cm. long. This stage marks the first appearance of the hæmal node in the neck, and shows the node in its simplest form, the follicle and its peripheral blood-sinus.

FIG. 514.—A DEVELOPING HÆMOLYMPH NODE.



There are wide variations in the **distribution** and number of the hæmolymph nodes; indeed, sufficient observations have not yet been made to determine their complete distribution. They have been divided into three groups, the prævertebral, the renal, and the splenic. In one subject, in which they were very numerous, they occurred at the root of the lung, near the bronchi and bronchial vessels, a few near the œsophagus, a continuous prævertebral chain in the abdomen extending from the diaphragm to the upper two or three sacral vertebræ, as well as a few along the cœliac axis and its branches, the superior mesenteric, renal, and iliac vessels (Lewis).

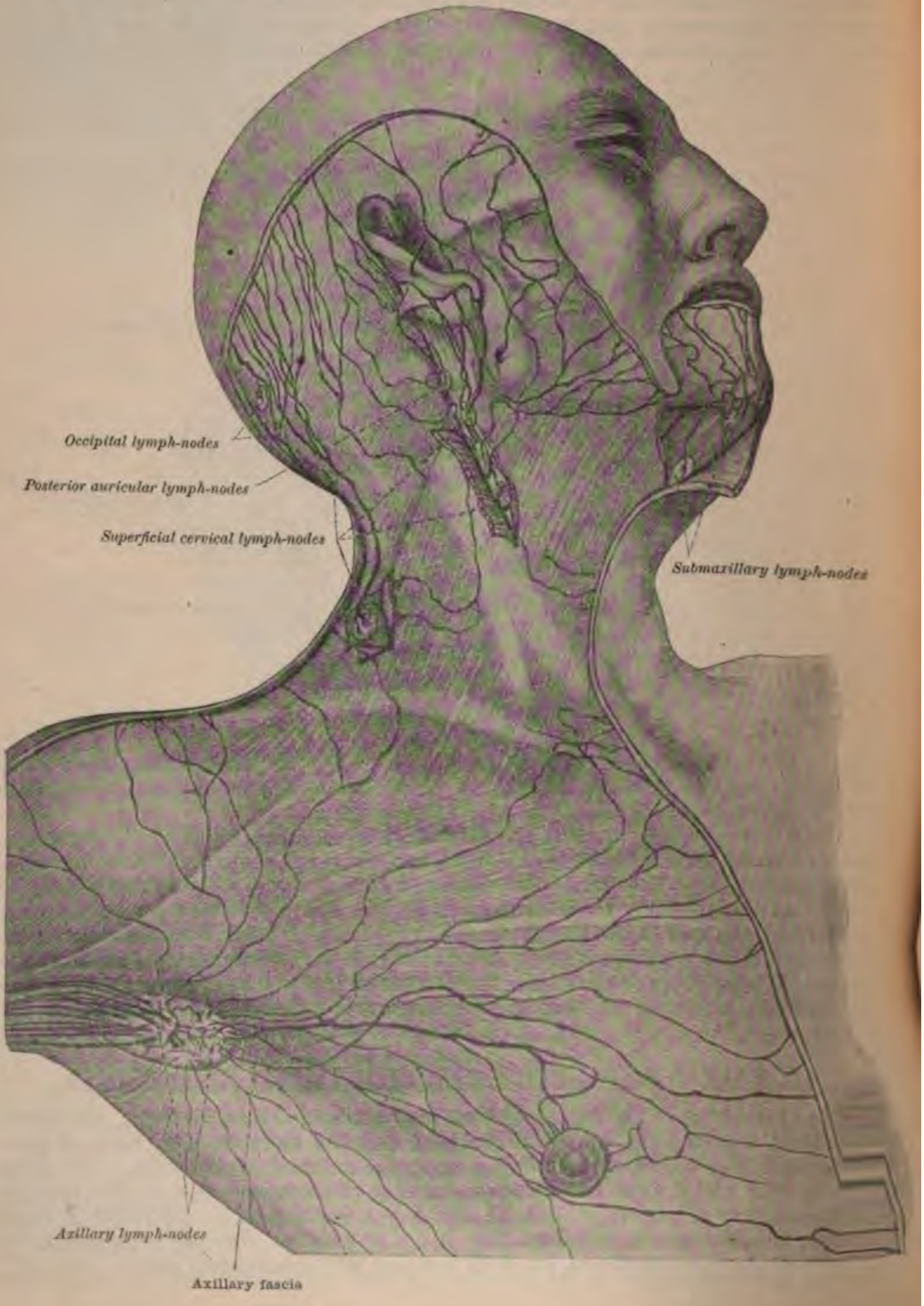
II. THE LYMPHATICS OF THE HEAD AND NECK

The lymphatics of the head and neck may be divided into two sets. One set is superficial, draining the entire skin surface, and has its nodes, for the most part, in the neck, the principal group lying along the external jugular vein. The other set is deeper and drains the mucous membrane of the upper part of the digestive and respiratory tracts, together with the deep organs, such as the thyreoid gland and the tendons of the muscles. The nodes of this set are deeply placed, being situated along the carotid arteries, with outlying retro-pharyngeal nodes.

I. THE SUPERFICIAL NODES OF THE HEAD AND NECK

Lymph-nodes appear first in the neck in the process of development. In the pig the first node to appear developes from the lymph heart, which is in the supra-clavicular triangle behind the sterno-cleido-mastoid muscle. From here ducts grow across

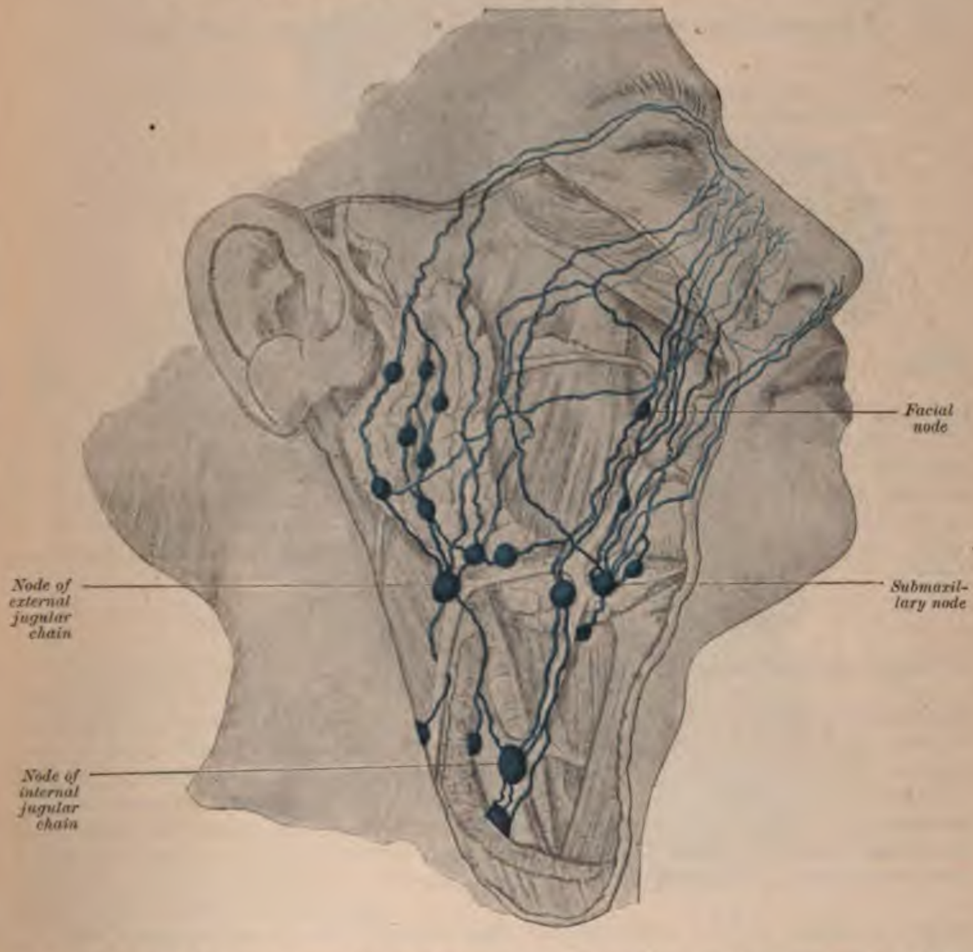
FIG. 515.—THE LYMPHATICS OF THE HEAD AND NECK. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Occipital lymph-nodes
Posterior auricular lymph-nodes
Superficial cervical lymph-nodes
Submaxillary lymph-nodes
Axillary lymph-nodes
Axillary fascia

the muscle and give rise to a chain of nodes along the external jugular vein. This chain is to be considered as the main chain of superficial nodes in the neck. From it lymphatic vessels grow over the back of the head, the side of the head, the face, and the front of the neck, and in their course groups of secondary nodes develope. The nodes of the main chain are known as the superficial cervical nodes, and are from four to six in number. The secondary groups are—(1) the occipital; (2) the posterior auricular; (3) the anterior auricular; (4) the parotid; (5) the submaxillary, with the facial as a tertiary set, and (6) the submental.

1. **The occipital nodes.**—The lymphatics of the skin of the back of the head collect into a few trunks that either empty into from one to three small nodes near the occipital insertion of the semispinalis capitis muscle, or pass by the secondary group and empty directly into the upper nodes of the main superficial cervical chain (fig. 515).

Fig. 516.—Lymphatics of the Face. (After Küttner.)


Facial node
Node of external jugular chain
Submaxillary node
Node of internal jugular chain

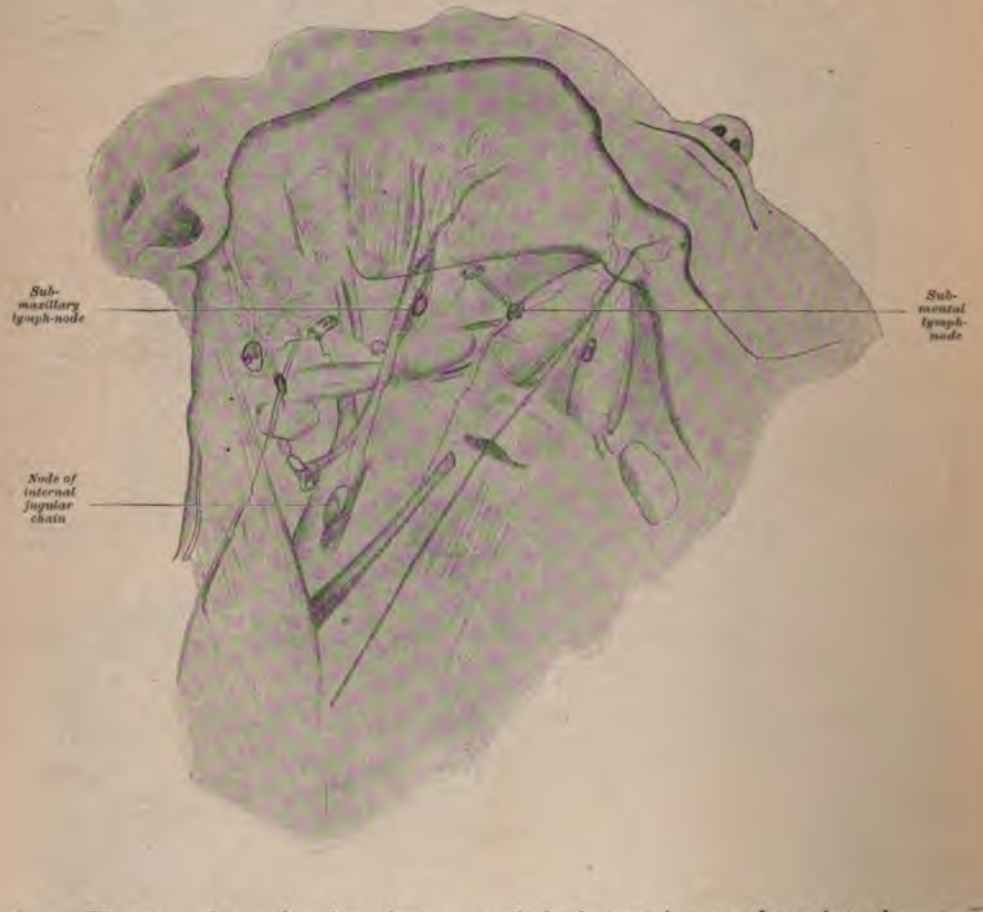
2. The **posterior auricular nodes.**—A portion of the temporal part of the scalp, together with the posterior surface of the ear, except the lobule, and the posterior surface of the external auditory meatus, drain into two small nodes on the insertion of the sterno-cleido-mastoid muscle. The efferent ducts of these nodes pass to the upper part of the superficial cervical chain.

3. The **anterior auricular nodes** are few in number — from one to three — and are situated immediately in front of the tragus of the ear. They receive ducts from the anterior surface of the pinna and the external auditory meatus, from the integument of the temporal region and the outer portion of the eyelids. Their efferents pass to the superior deep cervical nodes.

4. **The parotid nodes.**—The parotid group of nodes is considerably larger than the two preceding, containing from ten to sixteen nodes, and the group drains a more complex area. It receives ducts from the adjacent surface of the external ear, the external auditory meatus, the skin of the temporal and frontal regions, and the eyelids and nose. In the embryo these nodes lie in the pathway of the ducts that grow to the scalp; many of these ducts, however, pass the parotid group and empty into the superficial cervical chain. The nodes of the parotid group lie embedded in the substance of the parotid gland, and their efferents pass for the most part to the submaxillary nodes.

5. **The submaxillary and facial nodes.**—The submaxillary group consists of a chain of from three to six nodes, resting on the submaxillary gland, along the inferior border of the mandible. They lie usually on the submaxillary gland, but may extend from the insertion of the anterior belly of the digastric to the angle of the jaw. They are about the size of a pea, and the largest is near the point where t

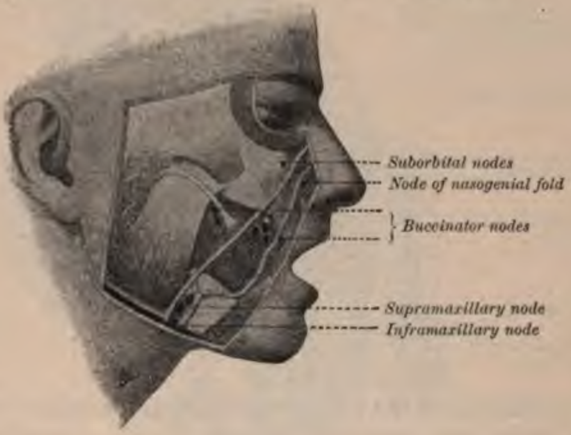
FIG. 517.—THE SUBMAXILLARY AND SUBMENTAL NODES. (After Slater.)



external maxillary (facial) artery crosses the mandible. The submaxillary nod together with the next group, the facial, drain a complex area, including not o skin, but mucous membrane. They receive ducts from the nose, cheek, upper l the external part of the lower lip, together with almost all those from the gums a from the anterior third of the lateral portions of the tongue. In agreement wi the fact that these nodes, though lying superficially and draining the skin, dra also the mucous membrane, their ducts empty not only into the superficial cervi chain, but also into the deep carotid chain.

The **facial nodes** are evidently outlying nodes of the submaxillary group. Th are in two main sets—(1) the **supra-maxillary set,** which consists of from one to th *teen nodes,* resting on the mandible near the point where it is crossed by the exter maxillary (facial) artery. (2) The **buccinator set,** lying on the line connecting the lower margin of the ear and the angle of the jaw. Of these latter nodes, some lie near the point where the parotid duct perforates the buccinator muscle; the others are farther forward, between the external maxillary artery and the anterior facial vein. Additional nodes belonging to the group may occur near the nose and in the suborbital region. These facial nodes receive afferents from the outer surface of the nose, the lips, eyelids, cheek, temporal part of the face, the mucosa of the mouth, the teeth of the upper jaw, the gums, the tonsils, and the parotid gland. Their efferents pass to the submaxillary and parotid nodes.

Fig. 518.—The Facial Nodes. (After Buchbinder.)



6. The **submental nodes,** usually two in number, lie in the triangle bounded by the anterior bellies of the two digastric muscles and the hyoid bone (fig. 517). They are usually near the median line, and drain the skin of the chin, the skin and corresponding mucous membrane of the central part of the lower lip and jaw, the floor of the mouth, and the tip of the tongue. The efferent ducts pass either to the submaxillary nodes or to the deep cervical chain.

II. THE LYMPHATIC VESSELS OF THE FACE

The different parts of the face and their relation to these groups of superficial nodes will now be considered.

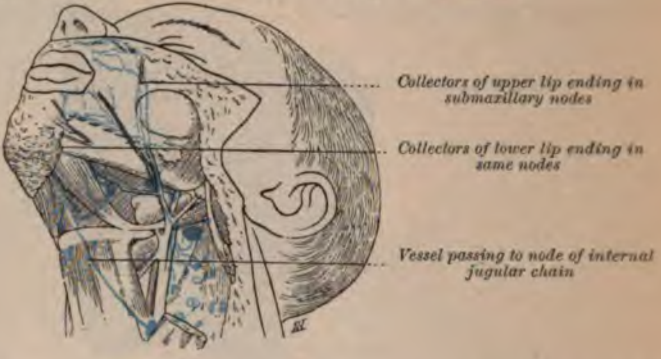
The **lymphatics of the scalp** form a rich network in the neighbourhood of the vertex, from which vessels pass in various directions. From the frontal region a number of ducts pass downwards and backwards to the parotid nodes; those from the parietal and temporal regions pass to the anterior auricular, parotid, and posterior auricular nodes; and those from the occipital region pass partly to the occipital nodes and partly to the superior deep cervical group, while a single large duct descends along the posterior border of the sterno-mastoid muscle to terminate in one of the inferior deep cervical nodes.

The lymphatics of the eyelids and conjunctiva. — The capillary plexus of the eyelids and the conjunctiva is an abundant one, and at the free border of the eyelids becomes extremely close. The ducts from the outer three-fourths of the lids pass to the anterior auricular and parotid groups of nodes, while those from the inner one-fourth pass obliquely across the cheek with the facial vein to terminate in the submaxillary nodes (fig. 516).

The lymphatics of the nose.—The lymphatics of the nose form a network which is coarse at the root of the organ, but dense over the alæ and lobule. The ducts run in three sets—(1) one set passing over the eye to the parotid nodes; (2) a set passing under the eye to the same nodes; and (3) the most important group, consisting of from six to ten trunks, passing to the facial and submaxillary nodes. There is some anastomosis between the capillaries of the skin and the mucous membrane of the nose.

The lymphatics of the lips.—The capillary plexuses of the skin and mucous membrane are continuous at the free border of the lips. The ducts of the upper lip, of which there are about four on each side, pass to the submaxillary nodes. From the lower lip the trunks from near the angle of the mouth pass to the submaxillary nodes, while those from the centre of the lip pass to the submental nodes. There are from two to four subcutaneous ducts and from two to three submucous ducts on either side. The collecting trunks passing to the submaxillary nodes do not anastomose, and the same is true of the submucous ducts of the lower lip. The subcutaneous ducts, on the other hand, passing to the submental nodes, anastomose freely, an important fact in connection with the extension of cancer of the lower lip.

Fig. 519.—The Lymphatics of the Lips. (After Dorendorf.)


Collectors of upper lip ending in submaxillary nodes
Collectors of lower lip ending in same nodes
Vessel passing to node of internal jugular chain

The lymphatics of the auricle and external auditory meatus.—The lymphatic plexus in the ear is an exceedingly abundant one. The collecting ducts pass to three sets of nodes:—(1) those from the external and internal surface of the auricle and the posterior part of the external auditory meatus pass to the posterior auricular nodes; (2) those from the lobule pass to the superficial cervical chain; some of the ducts from the first and second areas also run to the deep cervical group; (3) an anterior group from the concha, consisting of from four to six trunks, pass to the parotid nodes.

III. THE DEEP LYMPHATIC NODES OF THE HEAD AND NECK

The **deep cervical chain** is the largest mass of nodes in the neck. It consists of from fifteen to thirty nodes, which lie along the entire course of the carotid artery and internal jugular vein. This chain receives ducts from all the superficial nodes, also ducts directly from the skin, as well as from the entire mucous membrane of the respiratory and alimentary tracts in the head and neck. Thus it drains both the superficial and the deep structures.

For convenience of description this long chain, though usually continuous, is divided into two groups—(1) a superior group, lying above the level at which the omo-hyoid muscle crosses the carotid artery, and (2) an inferior or supra-clavicular group, lying below that level.

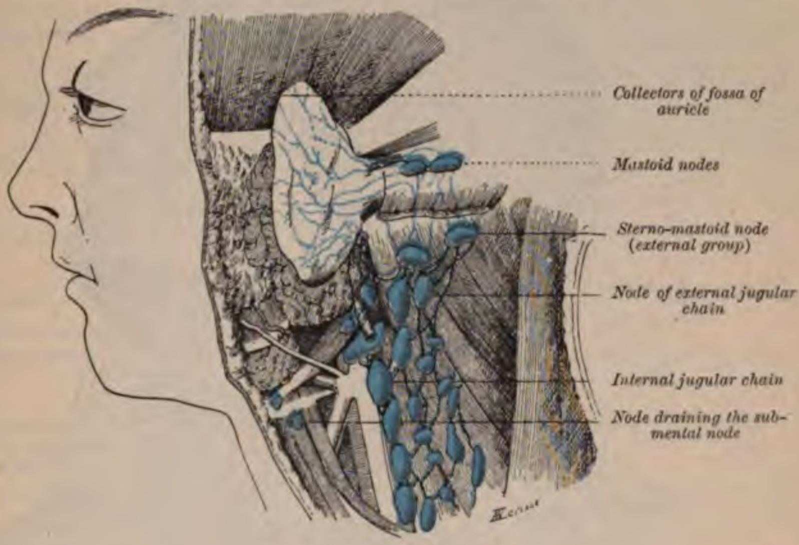
(1) **The superior deep cervical nodes.**—This group of nodes extends fro the tip of the mastoid process to the level at which the omo-hyoid muscle cross the common carotid artery. The *dorsal* and smaller nodes of the chain lie on t splenius, levator scapulæ, and scalene muscles. They drain the skin of the ba part of the head, both indirectly and directly, and receive (1) efferent ducts fro the occipital and posterior auricular nodes, (2) a large duct from the skin of t occipital part of the scalp, (3) some trunks from the auricle, and (4) cutaneous a muscular vessels from the neck.

The **ventral nodes** of the chain lie on the internal jugular vein. They dra the face both directly and indirectly, as well as the deeper structures of the hea and neck. They show especially well in fig. 523 in connection with the tongue.

(2) The **inferior deep cervical** or **supra-clavicular nodes** lie in the supr clavicular triangle. In the upper part of the triangle the nodes rest on the splen the levator scapulæ, and scalene muscles, while at the base of the triangle they a

related to the subclavian artery and the nerves of the brachial plexus. They drain a wide area, receiving vessels from the head, neck, arm, and thoracic wall. They are connected with the superior deep cervical chain, and receive afferents from the axillary nodes, and, in addition, they receive vessels directly from the back of the scalp, from the skin of the arm, and of the pectoral region. Thus it will be seen that a large part of the lymph of the head and neck, as well as some from the arm and thorax, pass through these nodes. Their efferent ducts unite to form the jugular trunk, which ends at the junction of the internal jugular and subclavian veins.

Fig. 520.—The Deep Cervical Chain. (After Poirier.)


Collectors of fossa of auricle
Mastoid nodes
Sterno-mastoid node (external group)
Node of external jugular chain
Internal jugular chain
Node draining the sub-mental node

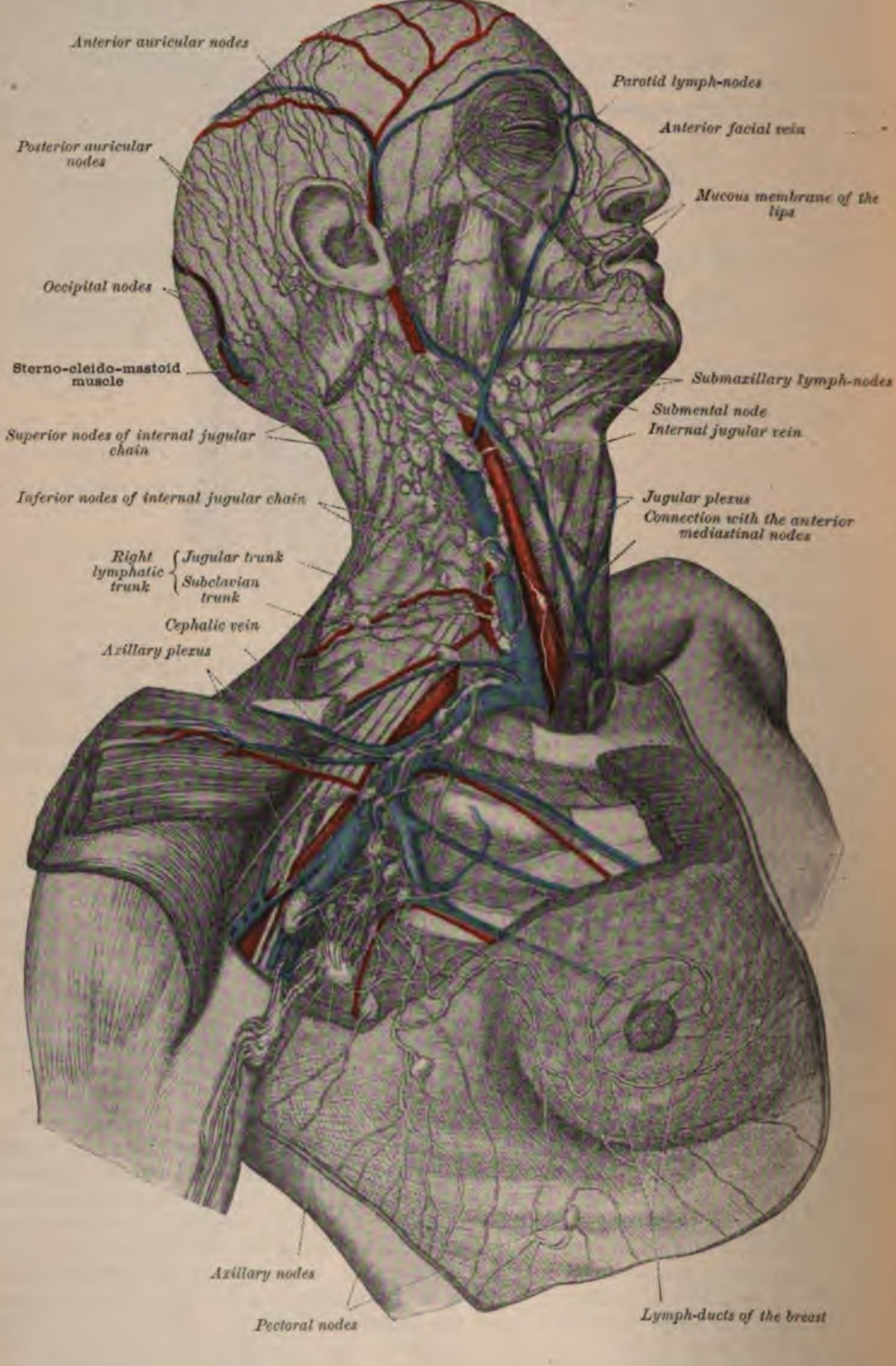
In the descriptions of the deep lymphatic vessels certain additional groups of nodes will be considered, which may be regarded as outlying groups from the deep cervical chain.

IV. THE DEEP LYMPHATIC VESSELS OF THE HEAD AND NECK

The lymphatics of the brain.—It is now recognised that there are no lymphatics in the brain and cord, so that the function of absorption must be accomplished by means of the veins. There is an abundant exudation of lymph around the nervous system into the subdural space, which is connected with the central canal of the nervous system, and which is to be considered as a zone in which the tissue-spaces are especially large. Along the arteries of the brain the adventitia is loose and open, possessing tissue-spaces which have received the confusing name of perivascular lymphatics. It would be better to name them perivascular tissue-spaces.

The lymphatics of the eye.—No lymphatic vessels have as yet been discovered either in the eyeball or in the orbit. In both, however, there are abundant tissue-spaces, the most noteworthy of the orbit being the **interfascial space (space of Tenon),** which communicates by a space between the optic nerve and its sheath with the subarachnoid spaces of the cranial cavity. In the eyeball the tissue-spaces are abundant, even if the vitreous and aqueous chamber be omitted from the category. Numerous spaces exist in the chorioid coat, especially in the lamina suprachorioidea, and in the sclerotic, both sets communicating by perivascular spaces surrounding the venæ vorticosæ with the interfascial space. In the cornea there are abundant lacunæ, united by their anastomosing canaliculi, to form a network of lymph-spaces which come into close relation with the conjunctival lymphatics at the corneal margin.

FIG. 521.—LYMPHATICS OF THE HEAD, NECK, AND AXILLA. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Anterior auricular nodes
Parotid lymph-nodes
Anterior facial vein
Posterior auricular nodes
Mucous membrane of the lips
Occipital nodes
Sterno-cleido-mastoid muscle
Submaxillary lymph-nodes
Submental node
Internal jugular vein
Superior nodes of internal jugular chain
Inferior nodes of internal jugular chain
Jugular plexus
Connection with the anterior mediastinal nodes
Right lymphatic trunk
Jugular trunk
Subclavian trunk
Cephalic vein
Axillary plexus
Axillary nodes
Pectoral nodes
Lymph-ducts of the breast

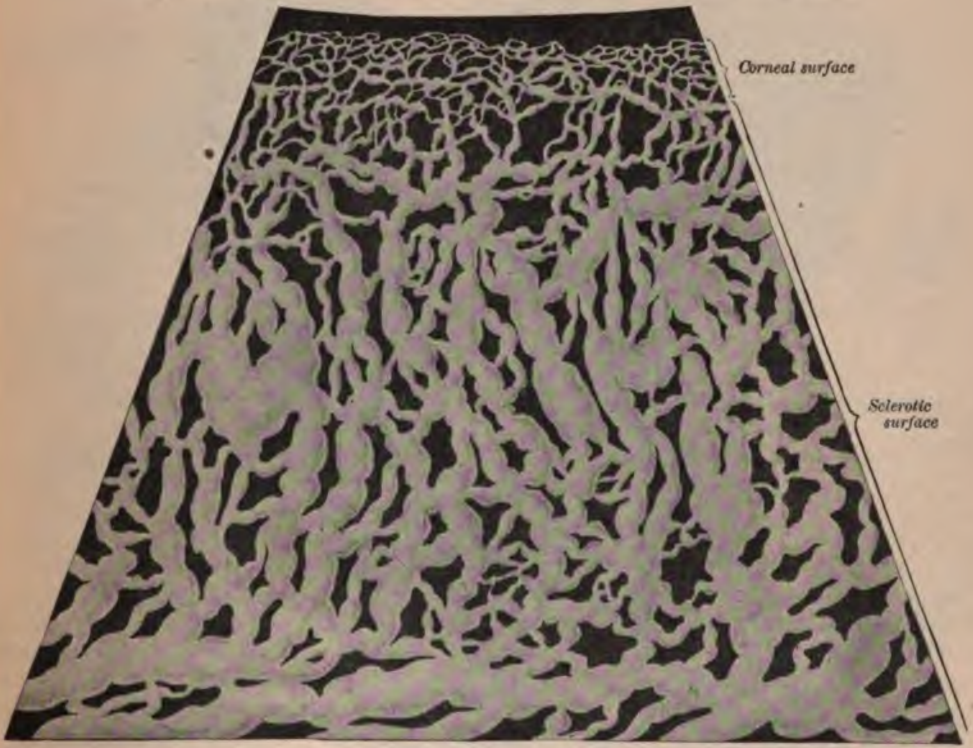
The conjunctiva, being a portion of the integument, does possess lymphatic vessels (fig. 522), arranged in a double network whose collecting ducts accompany those of the eyelids, and terminate with them in the submaxillary, posterior auricular, and parotid nodes.

THE LYMPHATICS OF THE DIGESTIVE TRACT IN THE HEAD AND NECK

The lymphatics of the gums.—The lymphatics from the mucous membrane of the gums pass to the submaxillary nodes. The capillary plexus is abundant; the collecting ducts arise from it on the inner surface of the gum, and pass between the teeth to reach a common semicircular collecting duct on the outer surface. Lymphatics have not yet been demonstrated in the pulp of the tooth.

The lymphatics of the tongue.—There is a rich lymphatic plexus throughout the entire extent of the submucosa of the tongue, but that portion lying in the basal part of the tongue seems to be more or less independent of the rest. There are four groups of collecting ducts—(1) Apical; (2) marginal; (3) basal; and (4) central.

FIG. 522.—THE LYMPHATICS OF THE CONJUNCTIVA. (After Teichmann.)



(1) The *apical ducts* are usually four in number, two on each side. One pair perforates the mylo-hyoid muscle and ends in a supra-hyoid median node, while the other pair pass to the deep cervical chain. The latter are long, slender vessels, which run along the frenum of the tongue to the surface of the mylo-hyoid muscle, cross the hyoid bone just behind the pulley of the digastric, and then run downwards in the neck to a node of the deep cervical chain, just above the omo-hyoid. It will be noted in fig. 523 that the most anterior ducts end in the lowest nodes, while those from the back of the tongue end in higher nodes.

(2) The *marginal ducts* are from eight to twelve in number. They all pass to the superior deep cervical nodes, a part of them passing external to the sublingual gland, while the larger number pass internal to it. There is one large and constant node at the point where the digastric muscle crosses the jugular vein, to which a large number of the ducts converge.

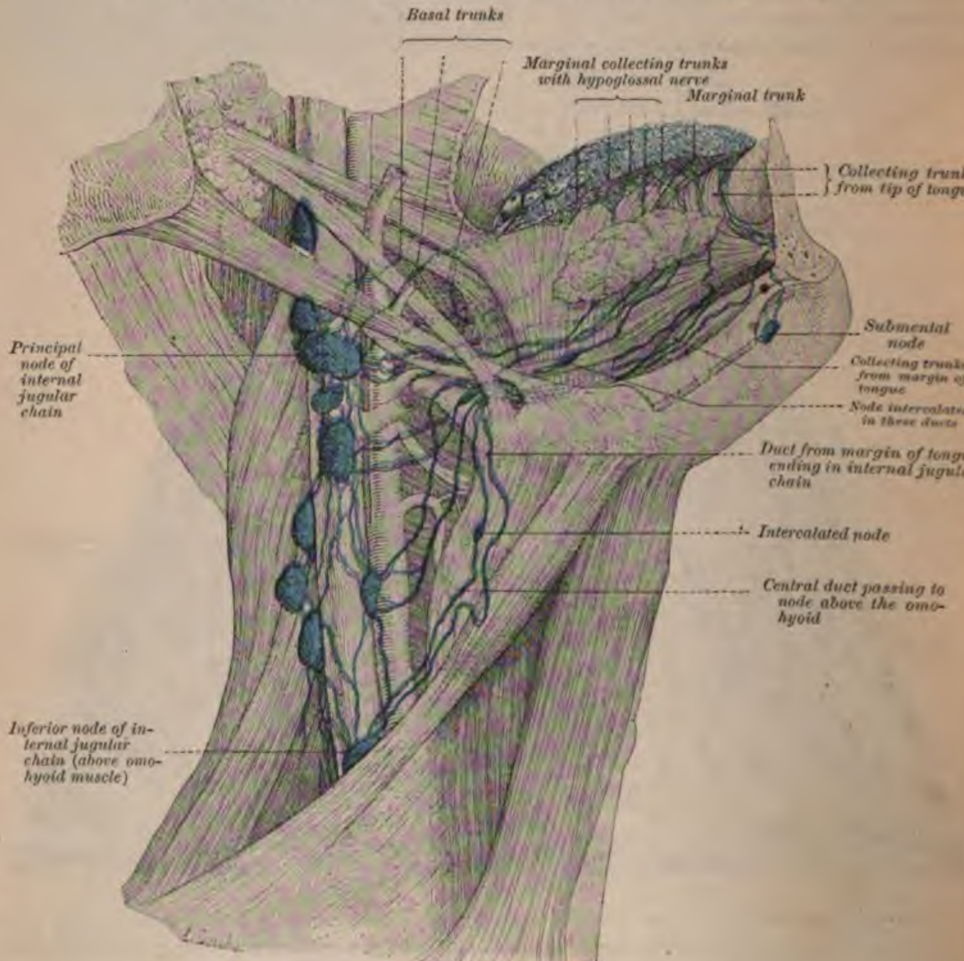
(3) The *basal ducts* are seven or eight in number, and drain the basal portion of

the tongue. Some end in the large node just mentioned, while others run backwards, close to the median line, where they anastomose, as far as the glosso-epiglottidean fold, when they separate and join the tonsillar vessels to pass outwards to the superior deep cervical nodes.

(4) The *central ducts*, arising from the central portion of the tongue, pass backwards in the median line on the ventral surface of the tongue. They lie upon the mylo-hyoid muscle, cross the hyoid bone, and end in the superior deep cervical chain.

The lymphatics of the palate.—The lymphatics from the palate pass to the deep cervical chain. The trunks from the hard palate run in the submucosa as far as the last molar tooth, where they pass in front of the anterior pillars of the fauces and end in the superior deep cervical nodes beneath the digastric muscle. In the soft palate the capillary plexus is very rich, reaching a maximum in the uvula. From the inferior surface of the soft palate and the pillars of the fauces vessels pass directly to the superior deep cervical chain, but some of the ducts from the upper surface of the soft palate run forwards with the pharyngeal vessels and end in the retro-pharyngeal nodes. It will be seen from fig. 524 that the retro-pharyngeal nodes are simply outlying nodes from the deep cervical chain.

FIG. 523.—THE LYMPHATICS OF THE TONGUE. (Poirier and Charpy.)

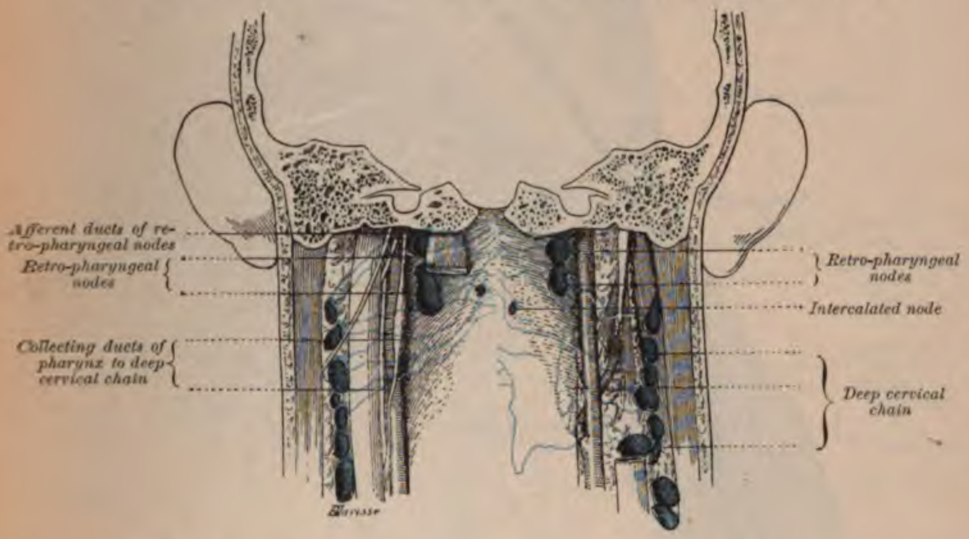

Basal trunks
Marginal collecting trunks with hypoglossal nerve
Marginal trunk
Collecting trunks from tip of tongue
Principal node of internal jugular chain
Submental node
Collecting trunks from margin of tongue
Node intercalated in these ducts
Duct from margin of tongue ending in internal jugular chain
Intercalated node
Central duct passing to node above the omo-hyoid
Inferior node of internal jugular chain (above omo-hyoid muscle)

The lymphatics of the pharynx.—As has just been stated, there are certain outlying nodes of the deep cervical chain which lie behind the pharynx. They receive some of the ducts from the submucosa of the roof of the pharynx, but many of the pharyngeal vessels pass by these nodes and end directly in the superior deep chain. The tonsil is especially rich in lymphatics, and its ducts, together with those from the middle and inferior portions of the pharynx, end in the superior deep cervical chain.

The lymphatics of the nasal cavities.—The mucous membrane of the nose contains a rich lymphatic plexus whose main ducts pass to the retro-pharyngeal nodes. An anterior set, however, anastomoses with the subcutaneous vessels, and through these their lymph is conveyed to the facial and submaxillary nodes. The posterior ducts run either to the deep cervical chain or to the retro-pharyngeal nodes. Key and Retzius have shown that an injection of the lymphatics of the nose may be made by injecting the subarachnoid spaces at the base of the brain, although there is presumably no direct connection between the spaces and the lymphatic vessels. The lymphatics of the nasal sinuses end in the retro-pharyngeal nodes.

The lymphatics of the larynx.—The larynx is, for the most part, drained by the deep cervical nodes, although its lymph may also pass through certain outlying nodes situated upon its ventral surface. The mucous membrane is divided into two zones by the false vocal cords, the mucous membrane of these structures possessing but a scanty lymphatic plexus. The ducts from the upper part of the larynx, four or five in number, pass to the nodes of the superior deep cervical chain, situated near the digastric muscle; those from the lower part pass to the lower nodes of the same chain, some even descending as far as the supra-clavicular nodes. The lymphatics of the trachea are scanty.

FIG. 524.—THE LYMPHATICS OF THE PHARYNX. (After Poirier and Cunéo.)


Afferent ducts of retro-pharyngeal nodes
Retro-pharyngeal nodes
Collecting ducts of pharynx to deep cervical chain
Retro-pharyngeal nodes
Intercalated node
Deep cervical chain

The lymphatics of the thyreoid body.—The lymphatics of the thyreoid body pass either to the small nodes situated in front of the larynx and trachea, or to nodes of the deep cervical chain, a part of them ascending and a part descending.

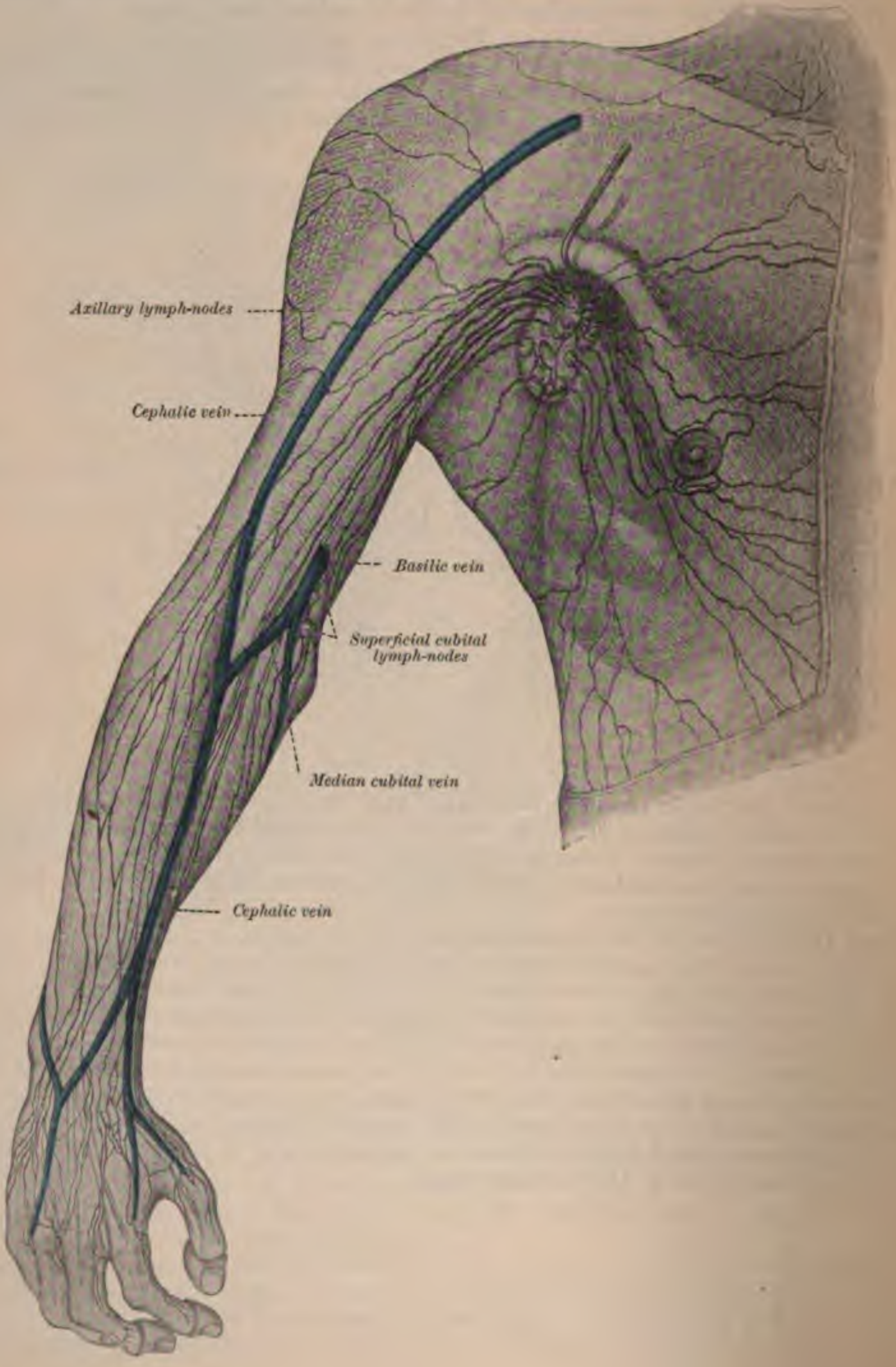
It will thus have been seen that the lymphatics of the mucous membrane of the head and neck all end in the deep cervical chain of nodes or in the outlying nodes from it. Some of the ducts pass by the outlying nodes, but since the nodes of the chain are so closely connected, the lymph must pass through several nodes before entering the veins. The main tonsils, the numerous lingual and pharyngeal tonsils, together with small lymph-follicles in the submucosa of the respiratory tract, represent lymph-nodes in the capillary zone.

III. THE LYMPHATICS OF THE UPPER EXTREMITY

I. THE LYMPHATIC NODES OF THE UPPER EXTREMITY

The lymph-nodes of the arm lie, for the most part, in the axilla, where there is a large group of nodes which receive almost the entire drainage of the arm and the thoracic wall. In addition, there are, in the arm, two sets of outlying superficial

Fig. 525.—The Lymphatics of the Arm. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Axillary lymph-nodes
Cephalic vein
Basilic vein
Superficial cubital lymph-nodes
Median cubital vein
Cephalic vein

nodes, the supra-trochlear and delto-pectoral nodes, and nodes occasionally occur on the vessels accompanying the brachial blood-vessels.

(1) The **supra-trochlear** or **superficial cubital node** is situated three or four centimetres above the medial epicondyle of the humerus. It is usually single, but may be absent or represented by a chain of from two to five nodes. Its afferent ducts follow the basilic vein.

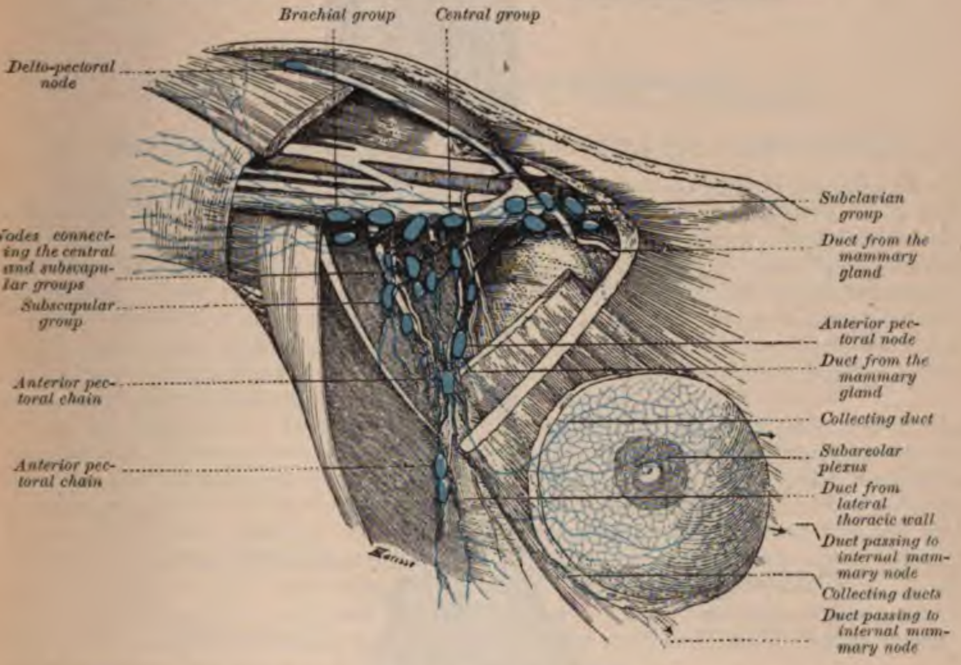
(2) The **delto-pectoral nodes** are from one to three in number, and are situated in the groove between the deltoid and pectoral muscles. Their ducts follow the cephalic vein.

(3) The **axillary nodes,** from twelve to thirty-six in number, may be divided into groups according to the areas which they drain (fig. 526).

(1) The *subclavian group* consists of four or five nodes, situated in the apex of the axillary fossa. They receive the efferent ducts of all the other groups, and their efferent ducts in turn unite to form a single trunk, the subclavian, which empties into the thoracic duct on the left side and on the right side either into the vein directly or else after uniting with the jugular trunk. (See p. 723.)

(2) *The central group.*—A little lower along the axillary artery is a group of three to five nodes, which makes a second centre for the ducts of the other groups, and sends its efferents to the subclavian group. It will be clear from the figure that the separation of groups 1 and 2 is arbitrary.

FIG. 526.—THE AXILLARY LYMPH-NODES. (After Poirier and Cunéo.)


Brachial group
Central group
Delto-pectoral node
Nodes connecting the central and subscapular groups
Subscapular group
Anterior pectoral chain
Anterior pectoral chain
Subclavian group
Duct from the mammary gland
Anterior pectoral node
Duct from the mammary gland
Collecting duct
Subareolar plexus
Duct from lateral thoracic wall
Duct passing to internal mammary node
Collecting ducts
Duct passing to internal mammary node

(3) *The brachial group.*—This consists of four or five nodes, and, as its position towards the junction of the axillary and brachial arteries indicates, is the main station for the ducts of the arm proper. It receives almost all the superficial and deep lymphatics of the arm, and its efferent ducts pass to the central and subclavian groups, although a few pass directly to the supra-scapular group.

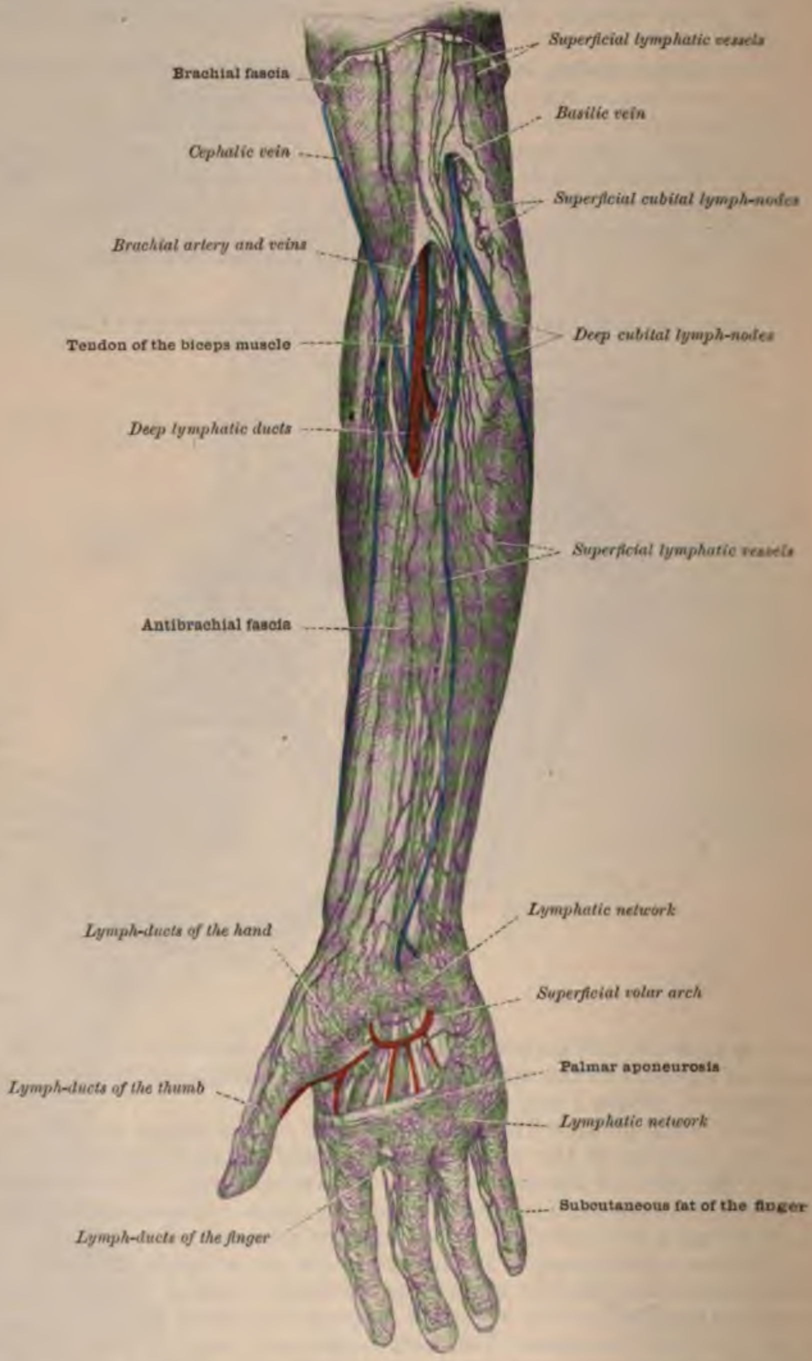
(4) *The subscapular group.*—In this group are six or seven nodes, which follow the subscapular artery and its branch, the circumflex (dorsal) scapular. Belonging to it there are usually two or three small nodes on the dorsal surface of the scapula, in the groove which separates the teres major and minor. This group receives ducts from the dorsal surface of the thorax, as well as from the arm, and its efferent ducts pass to the brachial group.

(5) *The anterior pectoral group.*—This group consists of four or five nodes which lie along the lower border of the pectoralis major and drain the mammary gland

and front of the chest. Their efferent ducts pass to the central and subclavian groups.

(6) The *posterior pectoral group* consists of small nodes situated on the inner wall of the axilla, along the course of the long thoracic artery. They receive afferents from the lateral integument of the thorax and drain into the nodes of the central group.

Fig. 527.—The Lypmhatics of the Lower Arm. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Superficial lymphatic vessels
Brachial fascia
Basilic vein
Cephalic vein
Superficial cubital lymph-nodes
Brachial artery and veins
Tendon of the biceps muscle
Deep cubital lymph-nodes
Deep lymphatic ducts
Superficial lymphatic vessels
Antibrachial fascia
Lymphatic network
Lymph-ducts of the hand
Superficial volar arch
Palmar aponeurosis
Lymph-ducts of the thumb
Lymphatic network
Subcutaneous fat of the finger
Lymph-ducts of the finger

II. THE LYMPHATIC VESSELS OF THE UPPER EXTREMITY

The superficial vessels.—The capillary network from which the superficial vessels arise is most dense on the palmar surface of the fingers, where the meshes are so fine that in a well-injected specimen they can be seen only with a lens. On the dorsal surface of the fingers the network is less dense. From the dorsal digital network two or three collecting ducts run along the sides of the fingers and ascend upon the back of the hand, while on the palmar surface the digital plexuses connect with a less dense plexus in the palm. At the wrist collecting ducts are formed which accompany the radial, median, and ulnar veins, and are continued in the upper arm, where they are joined by the few ducts from the dorsal surface, along the basilic and cephalic veins. All these trunks end in the brachial group of axillary nodes, except one or two which follow the cephalic vein to the delto-pectoral nodes, whence their lymph passes either to the subclavian nodes or else over the clavicle to the inferior deep cervical nodes.

The deep lymphatics.—The deep lymphatics of the arm follow the arteries and can be traced along the brachial and its branches to the deep palmar arch. Along the brachial trunks are one or two inconstant nodes.

IV. THE LYMPHATICS OF THE THORAX

I. THE SUPERFICIAL LYMPHATIC VESSELS OF THE THORAX

The superficial lymphatics of the thorax pass almost exclusively to the axillary nodes, and may be regarded as forming three sets, an anterior, a lateral, and a posterior. The **anterior set** drains the thoracic integument, which extends from the median line and the clavicle over to the lateral border of the chest, and includes the vessels of the mammary gland, which will, however, be described separately. The majority of the ducts from this area end in the anterior pectoral group of axillary nodes, a few, which arise beneath the clavicle, passing to the supra-clavicular nodes, and a few perforating the intercostal spaces and ending in the chain of nodes along the internal mammary artery.

It has been shown that an injection into the subcutaneous plexus near the median line passes to the opposite side, and that, in addition to the anastomosis between the networks of the two sides of the thorax which this result manifests, there may also be a few collecting trunks crossing the median line, and, furthermore, anastomoses occur between the superficial networks of the anterior thoracic and abdominal walls. Thus while the main channel of lymphatic drainage is through the axilla, there are minor accessory channels to (1) the supra-clavicular nodes, (2) to the axilla of the opposite side, (3) to the internal mammary chain, and (4) in isolated cases even to the inguinal nodes. These accessory channels may become more open in cases of obstruction to the main channel.

The **lateral set** of superficial thoracic lymphatics is much less extensive than the anterior, and its collecting ducts pass upwards to open into the posterior pectoral group of axillary nodes.

The **posterior set,** which occupies the subcutaneous tissue of the posterior thoracic wall, sends its ducts to the subscapular group of axillary nodes.

THE LYMPHATICS OF THE MAMMARY GLAND

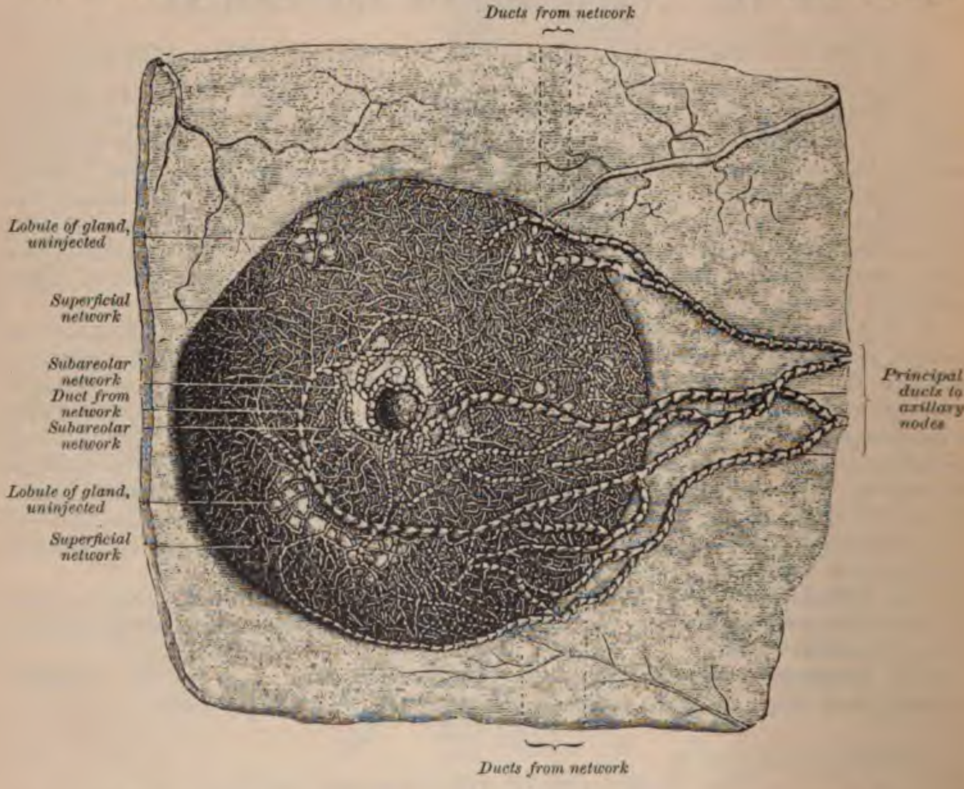
The lymphatic network over the peripheral portions of the mammary gland are exactly like those of the rest of the thoracic wall. In the areola, however, they are far more abundant, forming a double subareolar plexus. The superficial plexus is so dense that its meshes can be seen only with a lens. The deeper plexus not only drains the superficial plexus, but receives the ducts from the mammary gland itself, and from it arise two large trunks, one from the inferior and one from the superior part of the plexus. These two ducts pass to one or two of the nodes belonging to the anterior pectoral group of axillary nodes. In addition there may be—(1) One or two ducts passing to the nodes along the axillary artery; (2) in rare cases a duct may pass directly to the subclavian nodes. There is also a definite channel from the medial margin of the gland to the internal mammary nodes, the ducts following the perforating branches of the internal mammary vessels, and it may be noted that the crossed anastomosis and that with the abdominal network, mentioned in connection with the superficial thoracic vessels, may, on occasions, serve as channels for the mammary drainage.

Lymphatics of the thoracic muscles.—It is probable that the only lymphatic capillaries associated with muscles are those of the tendons. In the case of the pectoral muscles, the matter is of especial importance in connection with cancer of the breast. Oelsner has recently studied this question, and believes he has injected a capillary network in the thoracic muscles. This is doubtful, but, on the other hand, it is unquestioned that lymphatic ducts course through the pectoral muscles,—some passing to the axillary, others to the subclavian, and still others to the internal mammary chain of nodes.

II. THE LYMPHATIC NODES OF THE THORAX

The lymphatics of the thoracic cavity may be divided into two sets—the parietal and the visceral. The **parietal nodes** are arranged in two sets, the internal mammary chain and the intercostal nodes (fig. 530). Along the **internal mammary** artery are from four to six small nodes, which receive ducts from the anterior thoracic and the upper part of the abdominal walls, from the anterior diaphragmatic nodes which drain the liver, and from the mesial edge of the mammary gland. The efferent ducts usually unite with the ducts of the anterior mediastinal and bronchial nodes, to form the broncho-mediastinal trunk, which may join the thoracic duct on the left, or empties separately into the subclavian vein on both sides.

FIG. 528.—LYMPHATICS OF THE SUBAREOLAR PLEXUS OF THE BREAST. (After Sappey.)

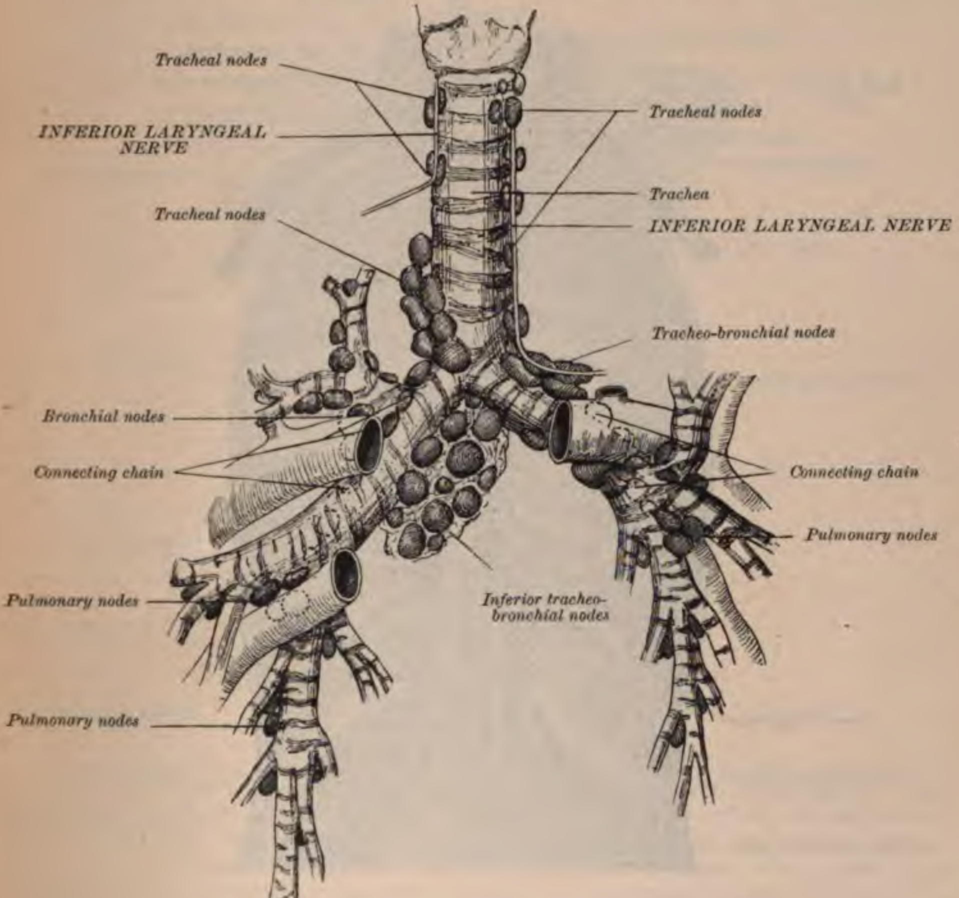


The **intercostal nodes** lie along the intercostal vessels, near the head of the ribs. There are two or three in each space, and occasionally a node is placed where the perforating lateral artery is given off. They drain the thoracic wall and costal pleura. Their efferent ducts enter the thoracic duct, those from the nodes of the lower four or five interspaces uniting to form a common duct which descends to the receptaculum chyli.

The **visceral nodes** of the thorax are arranged in three groups:—

1. The **anterior mediastinal nodes** are situated, as their name indicates, in the anterior mediastinum, and are arranged in an upper and a lower set. The upper set is situated upon the anterior surface of the arch of the aorta, and consists of eight or ten nodes, which receive afferents from the pericardium and the remains of the thymus gland. Their efferent ducts pass upwards to join the broncho-mediastinal trunk. The lower set consists of from three to six nodes, situated in the lower part of the mediastinum. They receive afferent ducts from the diaphragm, whence they are sometimes termed the **diaphragmatic nodes,** and also from the upper surface of the liver. Their efferents pass upwards to open into the supra-clavicular nodes.

FIG. 529.—THE TRACHEAL AND BRONCHIAL NODES. (Sukiennikow.)


Tracheal nodes
INFERIOR LARYNGEAL NERVE
Tracheal nodes
Trachea
Tracheal nodes
INFERIOR LARYNGEAL NERVE
Tracheo-bronchial nodes
Bronchial nodes
Connecting chain
Connecting chain
Pulmonary nodes
Pulmonary nodes
Inferior tracheo-bronchial nodes
Pulmonary nodes

2. The **posterior mediastinal nodes,** eight or ten in number, are situated along the thoracic aorta, and receive ducts from the mediastinal tissue and from the thoracic portion of the œsophagus. Their efferent ducts open directly into the thoracic duct.

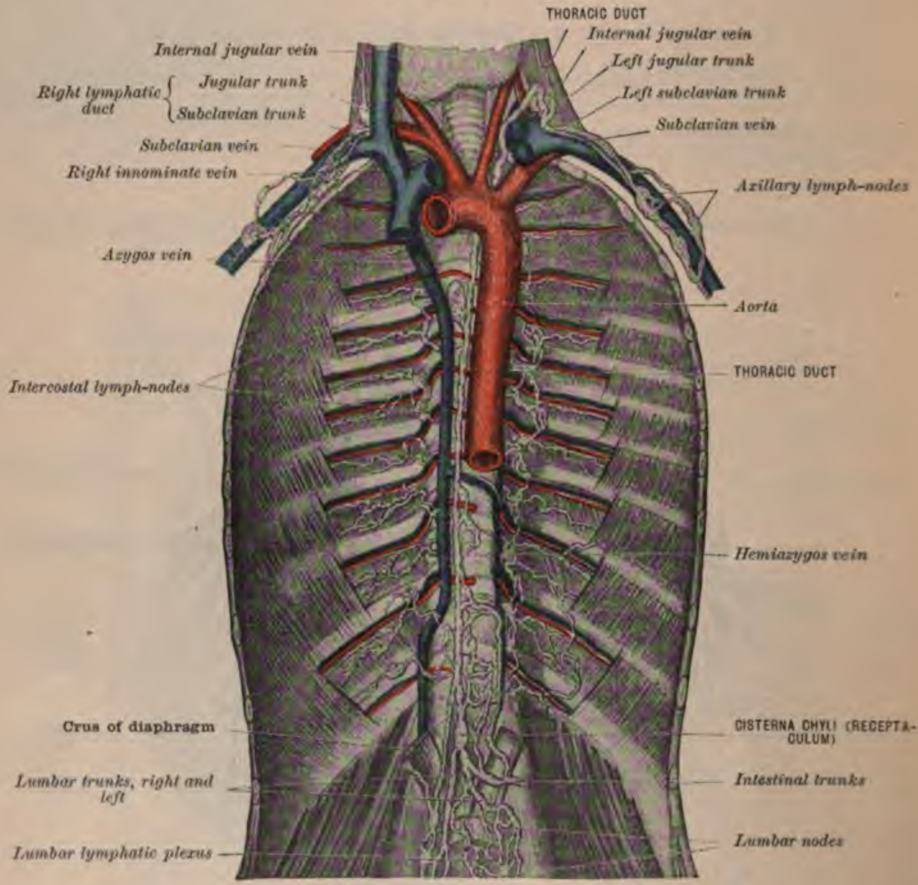
3. The **bronchial nodes** form an extensive group lying along the sides of the lower part of the trachea, and along the bronchi as far as the hilus of each lung, those lying in the hilus being termed the **pulmonary nodes.** They receive the

drainage of the lower part of the trachea, the bronchi, the lungs, and the heart, and their efferent ducts unite with those from the upper anterior mediastinal and internal mammary nodes to form the broncho-mediastinal trunk.

III. THE DEEP LYMPHATICS OF THE THORAX

In following the deep lymphatics of the thorax the course of development will be followed in describing first the thoracic duct and right lymphatic ducts, second the parietal vessels, and third the visceral vessels.

FIG. 530.—THE THORACIC DUCT. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

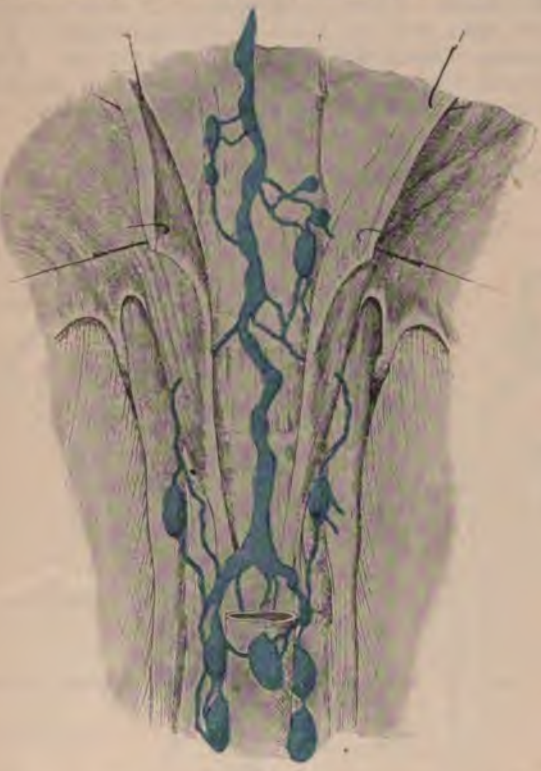

THORACIC DUCT
Internal jugular vein
Right lymphatic duct
Jugular trunk
Subclavian trunk
Subclavian vein
Right innominate vein
Azygos vein
Intercostal lymph-nodes
Crus of diaphragm
Lumbar trunks, right and left
Lumbar lymphatic plexus
Internal jugular vein
Left jugular trunk
Left subclavian trunk
Subclavian vein
Axillary lymph-nodes
Aorta
THORACIC DUCT
Hemiazygos vein
CISTERNA CHYLI (RECEPTACULUM)
Intestinal trunks
Lumbar nodes

THE THORACIC DUCT

The **thoracic duct,** which is the main collecting duct of the entire lymphatic system, extends from the second lumbar vertebra along the spinal column and course of the aorta to the junction of the left internal jugular and subclavian veins. It receives all the lymphatics below the diaphragm, and sometimes all the ducts of the left half of the body, above the diaphragm. At the lower end the duct is formed by the union of usually three collecting ducts, one from each of the lumbar groups of nodes, and an unpaired intestinal trunk. At its origin there is usually a dilated portion known as the **receptaculum** or **cisterna chyli.** This usually ends opposite the body of the eleventh thoracic vertebra, and from here on the duct is from 4 to 6 mm. in diameter, until near its termination, where it is again wider.

In its lower part, the duct lies behind the aorta in the median line; it passes through the aortic opening in the diaphragm, and then inclines to the right and passes upwards to about the fourth, fifth, or sixth thoracic vertebra, when it bends to the left and passes, continuing upwards, over the apex of the left lung and the left subclavian artery, and in front of the root of the left vertebral artery, and then curves downwards to open into the left subclavian vein, close to its junction with the left internal jugular. The duct runs in the wall of the vein a short distance before ending. Inasmuch as the thoracic duct developes as a plexus of ducts on the wall of the aorta, there is a wide range of variation from this usual course. The duct is frequently double, the two branches being connected by cross anastomoses, and finally uniting into a single trunk before joining the veins. It may be multiple, or a single trunk may pass in front of the aorta instead of behind. There is also a wide range of variation in the height to which the duct ascends in the neck before curving downwards to the vein. As regards the termination of the thoracic duct, variations are less common, although it may bifurcate and end as two ducts. It is rare to see connections with veins other than the subclavian. According to Henle, there is one undoubted case reported of a thoracic duct ending in the azygos vein near the sixth thoracic vertebra, the duct being obliterated above this point. At the terminal bend the thoracic duct receives the jugular trunk from the neck; it may also receive the subclavian and the broncho-mediastinal trunks, but it is more usual for these last two to open either separately or together into the subclavian.

FIG. 531.—ABDOMINAL PORTION OF THE THORACIC DUCT. (Poirier and Cunéo.)



THE RIGHT LYMPHATIC DUCT

On the right side the jugular, subclavian, and broncho-mediastinal trunks usually open separately into the subclavian vein, the orifices of the first two being near together. When the jugular and subclavian trunks unite, the common duct is termed the right lymphatic duct; this is a rare form, and it is still more rare for the three ducts to unite to form a common stem.

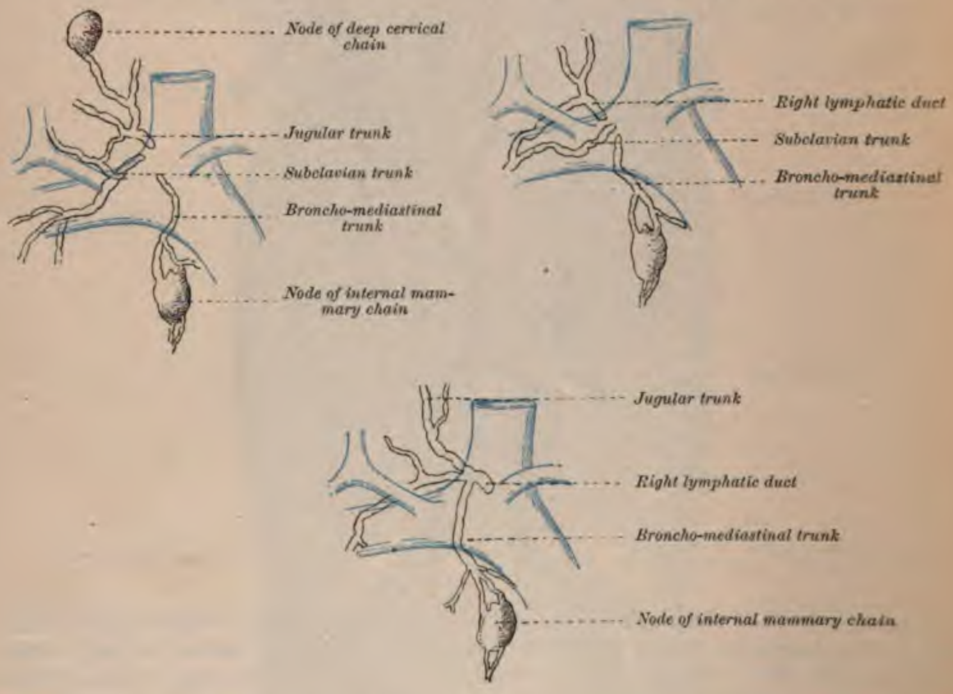
The Deep Lymphatic Vessels

As with the nodes, the deep lymphatic vessels of the thorax may be divided into a parietal and a visceral group. To the former group may be assigned the lymphatics of the intercostal spaces and those of the diaphragm.

The **intercostal lymphatics** form plexuses in each intercostal space, from which the drainage is either anteriorly or posteriorly. From the posterior half of each space the drainage is to the intercostal nodes, while from the anterior half it is towards the internal mammary nodes.

The lymphatics of the diaphragm.—There is an exceedingly rich plexus of capillaries both on the pleural and on the abdominal surface of the diaphragm, these plexuses lying in the subserous layers and being freely connected by vessels which perforate the muscle. There is, however, only slight communication between the plexuses of the right and left sides of the diaphragm. The collecting ducts empty into three groups of small nodes on the convex surface. The *anterior group* lies in front of the central tendon. Two or three nodes in the centre of this group receive afferents from the liver and none from the diaphragm, but the rest receive ducts from the anterior surface of the diaphragm and the efferents of all pass to the lower set of anterior mediastinal nodes.

Fig. 532.—Terminal Collecting Ducts on the Right Side. (Poirier and Cunéo.)


Node of deep cervical chain
Jugular trunk
Subclavian trunk
Broncho-mediastinal trunk
Node of internal mammary chain
Right lymphatic duct
Subclavian trunk
Broncho-mediastinal trunk
Jugular trunk
Right lymphatic duct
Broncho-mediastinal trunk
Node of internal mammary chain

The *middle group* consists of from three to six nodes, which lie, on the left side, near the point where the phrenic nerve enters the diaphragm; on the right side, near the vena cava.

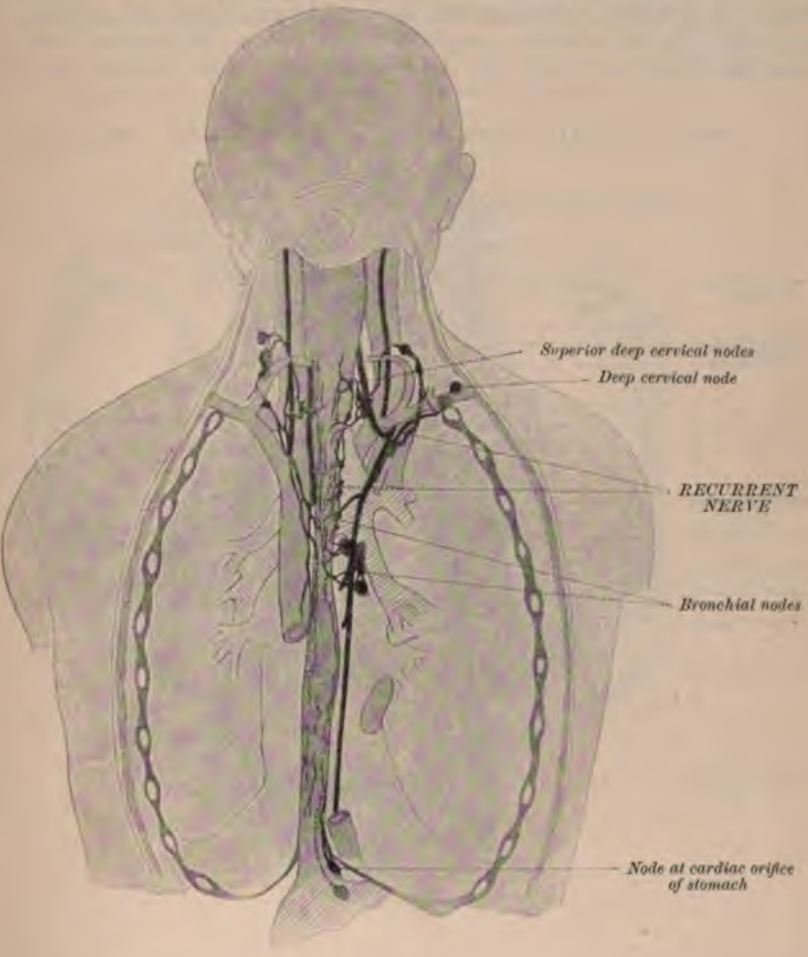
The *posterior group* of four or five nodes is placed between the pillars of the diaphragm. The ducts from the lateral and posterior groups pass to the posterior mediastinal nodes, and also to the upper cœliac nodes, which likewise receive the drainage from the posterior part of the abdominal surface of the diaphragm.

To the visceral group of thoracic lymphatics belong the vessels of the lungs, the heart, and the œsophagus.

The **lymphatics of the lungs** are arranged in two sets. A *deep set* takes its origin in plexuses which surround the terminal bronchi and follow the course of the bronchi to t[illegible] odes at the hilus, whence the stream passes to the main bronchial nodes, especially to those situated in the angle formed by the bifurcation of the trachea, and thence to the broncho-mediastinal trunk. A *superficial set* arises in a network situated upon the surface of the lung beneath the visceral layer of the pleura. No communications exist between this set and the deep one, but its collecting stems pass independently to the pulmonary nodes.

Lymphatics of the heart.—The lymphatics of the heart need reinvestigation. There are no capillaries in the musculature, but there is a rich plexus of vessels on the surface of the ventricles, and the ducts follow the course of the coronary arteries. Two collecting ducts leave the base of the heart on either side, and pass backwards and upwards on the side of the pulmonary artery to the bronchial nodes at the bifurcation of the trachea.

FIG. 533.—THE LYMPHATICS OF THE ŒSOPHAGUS. (After Sakata.)


Superior deep cervical nodes
Deep cervical node
RECURRENT NERVE
Bronchial nodes
Node at cardiac orifice of stomach

The **lymphatic vessels of the œsophagus,** which will here be considered throughout its entire extent, cervical as well as thoracic, are arranged in two plexuses, one of which occurs in the mucosa and the other in the submucosa. The collecting ducts arising from the plexuses may be divided into three sets, of which the uppermost pass to outlying nodes belonging to the deep cervical chain, those from the thoracic portion of the tube pass to the posterior mediastinal nodes, while those from its lowermost part pass to the superior gastric nodes (fig. 533).

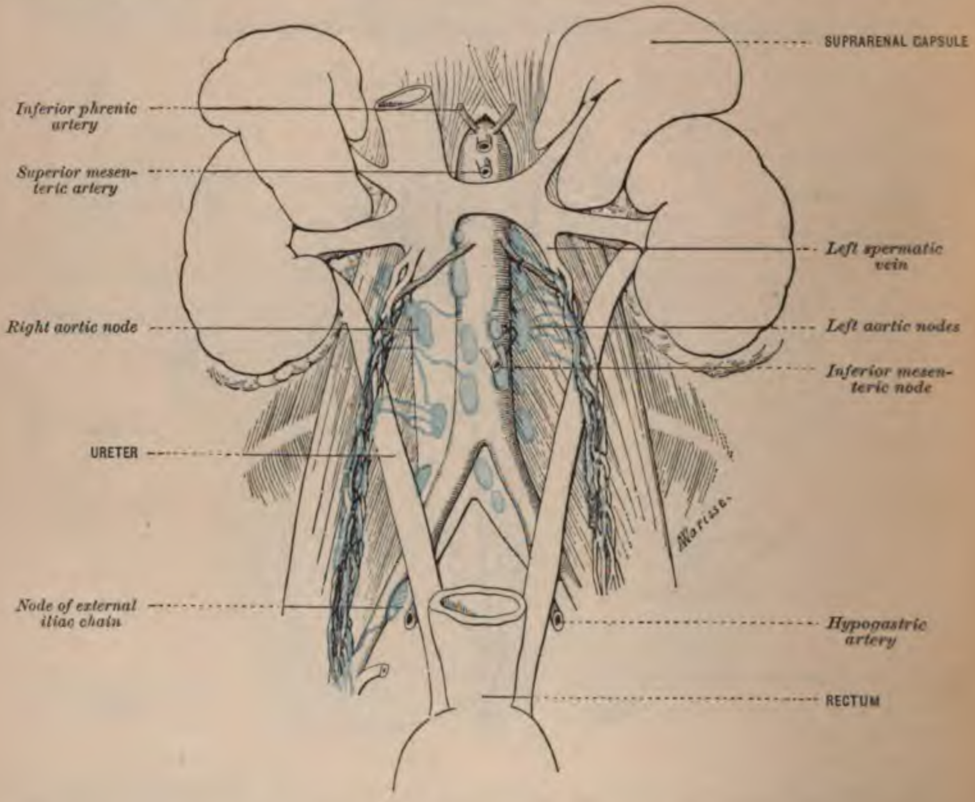
V. THE LYMPHATICS OF THE ABDOMEN AND PELVIS

I. The Lymphatic Nodes of the Abdomen and Pelvis

The lymphatics which develope directly from the thoracic duct, though complicated, may be described in a word by saying that they follow the aorta and its branches. In the abdomen there are four main chains along the aorta—(1) the left lumbar chain; (2) the right lumbar chain; (3) the pre-aortic chain; and (4) the post-aortic chain.

The right and left lumbar nodes form an almost continuous chain along the abdominal aorta, resting upon the psoas muscles, some of those on the right side being in front and some behind the inferior vena cava. They receive—(1) the efferent lymphatics of the common iliac nodes, and hence drain the leg and external genitalia; (2) the efferent lymphatics that follow the lumbar arteries and hence drain the abdominal wall; (3) the efferent ducts that followed the paired visceral aortic branches, namely, the ducts from the kidneys, supra-renal, and internal reproductive organs. On the right side, the lymphatics from the reproductive organs pass to the nodes in front of the vena cava—those of the abdominal walls pass to the posterior set, while those from the kidney pass to both sets.

Fig. 534.—Abdominal Aortic Nodes in the New-born. (Poirier and Charpy.)


SUPRARENAL CAPSULE
Inferior phrenic artery
Superior mesenteric artery
Left spermatic vein
Right aortic node
Left aortic nodes
Inferior mesenteric node
URETER
Node of external iliac chain
Hypogastric artery
RECTUM

The efferent vessels of the lower lumbar nodes pass to higher ones and so on up the chain, the vessels from the uppermost nodes uniting to form a single **lumbar trunk** on each side. These trunks pass to the thoracic duct, forming two of the so-called trunks of origin of that vessel (fig. 531).

The **pre-aortic nodes** are arranged in three groups at the root of each of the three unpaired visceral branches of the aorta—the cœliac, the superior mesenteric, and the inferior mesenteric arteries. The **cœliac nodes** are from one to three in number.

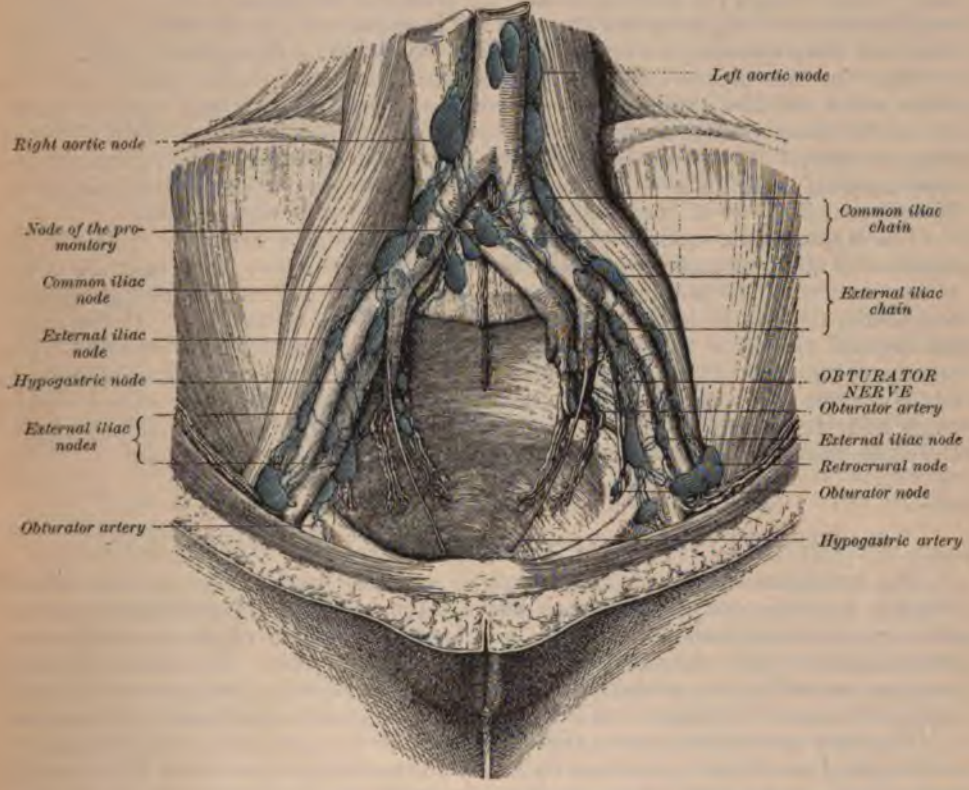
and are in reality part of chains of nodes extending along the branches of the artery and constituting the **hepatic, gastric,** and **splenic** nodes. They drain the stomach, duodenum, liver, pancreas, and spleen.

The **superior mesenteric** group is larger, and is continuous with the **mesenteric nodes** lying in the root of the mesentery. This group drains the remainder of the small intestine, the cæcum and appendix, the ascending and transverse colons, and the pancreas.

The **inferior mesenteric** group usually has two nodes, one on either side of the artery. It drains the rectum and descending and sigmoid colons. All the nodes in the mesentery and intestinal walls may be considered as outlying nodes of the pre-aortic group. They will be studied in connection with the visceral lymphatics.

The inferior mesenteric nodes drain into the neighbouring lumbar nodes, and also directly upwards to the superior mesenteric nodes, and then again to the cœliac nodes. From the last a single stem, the **intestinal trunk,** arises and passes either to the right lumbar trunk or directly to the thoracic duct, forming the third of the so-called trunks of origin of the duct.

FIG. 535.—ILIO-PELVIC NODES. (Cunéo and Marcille.)


Left aortic node
Right aortic node
Node of the promontory
Common iliac chain
Common iliac node
External iliac chain
External iliac node
Hypogastric node
OBTURATOR NERVE
Obturator artery
External iliac nodes
External iliac node
Retrocrural node
Obturator node
Obturator artery
Hypogastric artery

The **post-aortic nodes** are not true regional nodes, but receive ducts from the lumbar and pre-aortic chains.

Below the bifurcation of the aorta there are three large chains, the common iliac, the external iliac, and the hypogastric.

The **common iliac nodes** are in three groups. The *external* set consists of about two nodes, which are in reality a part of a continuous chain extending along the side of the aorta, common iliac, and external iliac arteries. A second set of two to four *posterior nodes* lies behind the artery. These two groups receive the efferent ducts of the external iliac and hypogastric chains. The *internal* set usually consists of two nodes which rest upon the promontory of the sacrum. They receive ducts from the sacral nodes, together with most of those from the pelvic viscera, namely, from the prostate, neck of the bladder, neck of the uterus, the vagina, and part of the rectum. The efferent ducts of the common iliac nodes pass to the lumbar chain.

External iliac nodes.—These are likewise in three sets—external, middle, and internal. The *external* chain consists of three or four nodes, the lowest one being behind the crural arch. They receive—(1) some of the ducts of the superficial and deep inguinal nodes; (2) ducts from the glans or clitoris, which come through the inguinal canal; (3) ducts from the part of the abdominal wall supplied by the deep epigastric and deep circumflex arteries, along which there may be a few outlying nodes—the **epigastric nodes.**

The *middle* chain consists of two or three nodes behind the artery. When there are three, the lowest is likewise near the crural arch. It receives vessels from the bladder, prostate, neck of the uterus, and upper portion of the vagina. The *internal* chain consists of three or four nodes, and is the continuation of the deep inguinal nodes. Its lowest nodes are likewise near the femoral ring, while the next node is large and constant, and usually lies within the pelvis. This chain receives many ducts:—(1) Ducts from the superficial and deep inguinal nodes; (2) from the glans and clitoris through the femoral canal; (3) from the abdominal wall; (4) from the neighbourhood of the obturator vessels; (5) from the neck of the bladder, the prostate, and membranous part of the urethra; (6) from the hypogastric chain.

Thus, to sum up the nodes of the external iliac chains:—they are a part of a chain which includes the lumbar, common iliac, external iliac, and inguinal nodes. It will be noted that this extensive chain stops, for the most part, with the deep inguinal group. The external iliac nodes receive the efferents of the superficial and deep inguinal nodes; the middle and internal groups receive ducts from the pelvis. The efferent ducts of all the nodes in the chain pass to the higher nodes.

The **hypogastric nodes.**—These nodes are in groups near the origin of the branches of the hypogastric (internal iliac) artery. Thus they occur near the origin of the obturator, the uterine, or prostatic, the trunk of the inferior gluteal (sciatic) and pudic, the middle hæmorrhoidal, and the lateral sacral arteries. All the nodes are beneath the pelvic fascia, and are connected by numerous anastomoses. They receive lymphatics from the structures drained by the corresponding arteries, namely, from the pelvic viscera, the perineum, and the posterior surface of the thigh and gluteal region. Their efferent ducts pass partly to the middle group of the common iliac nodes, and also to the posterior nodes of the same chain.

II. THE LYMPHATIC VESSELS OF THE ABDOMINAL WALLS

The lymphatic vessels of the abdominal walls are arranged in two sets, one of which is subcutaneous and the other deep or aponeurotic. The **subcutaneous** vessels form a rich network through all the subcutaneous tissue of the abdomen, anastomosing above with the subcutaneous plexus of the thorax. The collecting ducts converge towards the inguinal region, those from the posterior wall curving forwards along the crest of the ilium, and they all terminate in the superficial inguinal nodes.

The **deep** vessels drain along three principal lines. (1) A set of collecting ducts follows the line of the deep epigastric artery to terminate in the lower external iliac nodes; (2) a second set follows the deep circumflex iliac vessels to the same nodes; and (3) a third set follows the lumbar vessels to terminate in the nodes of the lumbar chain. A group of small **epigastric nodes,** which may be regarded as offsets from the iliac chain, occur on the ducts which accompany the deep epigastric vessels, not far from their termination, and a second less constant group of usually three small **umbilical nodes** occurs in the vicinity of the umbilicus in the network covering the posterior layer of the sheath of the rectus abdominis muscle.

III. THE VISCERAL LYMPHATIC VESSELS OF THE ABDOMEN AND PELVIS

The lymphatics to the viscera follow along the course of the arteries. At the point where the artery of an organ branches from the aorta there is a group of nodes which represents the main regional group, and a second chain of nodes extends along the artery. The final arrangement of nodes and ducts varies with each organ. Though the ducts follow the blood-vessels, the lymphatic capillaries in the regions where their relations are known are separated from the vascular capillaries; in the intestinal villi, for example, the lymphatic capillaries are central, while the vascular capillary plexuses are peripheral. The relation of the lymphatic capillaries to the essential structures of each organ, that is to say, the arrangement of the lymphatics in the absorbing area, is not yet clear in many organs, and this is a point which can be worked out by tracing the development and gradual invasion of each organ by the lymphatics. The old theory of the origin of the lymphatics from the tissue-spaces made this problem most difficult for attack.

In almost all organs there is a peripheral or capsular lymphatic plexus, which anastomoses with the parietal lymphatics, these anastomoses being particularly well developed in the case of the liver. In addition there are one or two deep plexuses in the great majority of the organs which drain partly directly to their regional nodes and partly by way of the peripheral plexus.

The Lymphatics of the Alimentary Tract

The lymphatics of the mouth, pharynx, and œsophagus have already been described (pp. 713, 725). In general, throughout the abdominal part of the alimentary canal, the distribution of nodes is as follows:—(1) There are primary regional nodes situated at the roots of the arteries as they leave the aorta, that is to say, around the cœliac and the superior and inferior mesenteric arteries; these drain large segments of the intestine; (2) groups of definite and constant nodes placed along the branches of the arteries in the root of the mesentery; these drain a definite smaller segment of the intestine; (3) chains of nodes along the anastomotic loops of the arteries, close to the intestinal wall; these are of the type called 'intercalated nodes'; (4) nodes which are either solitary or compound follicles, situated within the submucosa or capillary zone of the lymphatics.

What may be taken as the typical arrangement of the lymphatic vessels in the intestine may be seen in fig. 536. There are three zones in which the capillary plexuses are spread out, namely, in the subserosa, the submucosa, and the mucosa. There is an abundant plexus of large capillaries just beneath the serosa; in the submucosa the plexus is also formed by large capillaries, while the mucosal plexus is finer. The lymph-follicles lie in the zone of the mucosal plexus, and it is from this that the central chyle vessels of the villi arise. The collecting ducts are formed by the union of ducts from the submucous and subserous plexuses. They traverse the three sets of nodes just described.

The lymphatics of the stomach (fig. 537).—The stomach differs from the rest of the alimentary canal in its blood-supply in having a ventral anastomotic loop, namely, that along the lesser curvature. Along this loop is the **superior gastric chain** of nodes, lying between the folds of the lesser omentum, some of them being on the posterior surface of the stomach. This is the most important group of nodes draining the stomach, and it has been shown that the ducts from the pylorus run obliquely across the stomach to the main mass of nodes near the cardia, an important point in the surgery of the pylorus. The efferent ducts of the chain pass to the cœliac nodes. The ducts of the greater curvature pass to a group of **inferior gastric nodes** situated along the right epiploic artery, while the ducts of the fundus follow the short gastric and left gastro-epiploic vessels to the nodes which lie along the splenic artery, both these sets of nodes also draining to the cœliac group. There is a zone half-way between the lesser and greater curvatures, in which the lymphatics are scanty. The lymphatics of the cardia connect with those of the œsophagus, and the mucosal plexus of the pylorus is continuous with that of the duodenum.

The lymphatics of the duodenum.—The lymphatics of the duodenum depart somewhat from the type, owing to its relations to the pancreas and to the bile-ducts. The collecting ducts end—(1) in nodes in front of the pancreas, which follow the pancreatico-duodenal artery to the hepatic chain; (2) in nodes behind the pancreas, which follow the superior mesenteric artery to the superior mesenteric nodes. There are anastomoses between the lymphatics of the duodenum and those of the pylorus, of the pancreas, and of the chain along the common bile-duct.

The **lymphatics of the jejuno-ileum** (fig. 538) have already served as the type of the arrangement of the intestinal lymphatics (see above). The mass of mesenteric nodes to which the lymphatics of the small intestine pass is the largest and one of the most important in the body, its individual nodes numbering anywhere from 130 to 150.

The lymphatics of the ileocæcal region.—The surgical importance of the lymph-nodes in connection with the appendix warrants a detailed description of them in which the observations of Brödel will be followed. The drainage of the cæcum and appendix is along the ileo-colic artery, and is carried on by three sets of collecting ducts—(1) an anterior cæcal set, which generally pass through one or more outlying nodes before reaching the ileo-cæcal mesenteric nodes; (2) a similar posterior set; and (3) an appendicular set, three to six in number, which usually pass directly to the ileo-cæcal nodes. The appendix thus has an independent drainage into one or two ileo-cæcal nodes, about 3 cm. above the ileum. The ileo-cæcal chain drains through the mesenteric nodes to the superior mesenteric group (figs. 539, 540).

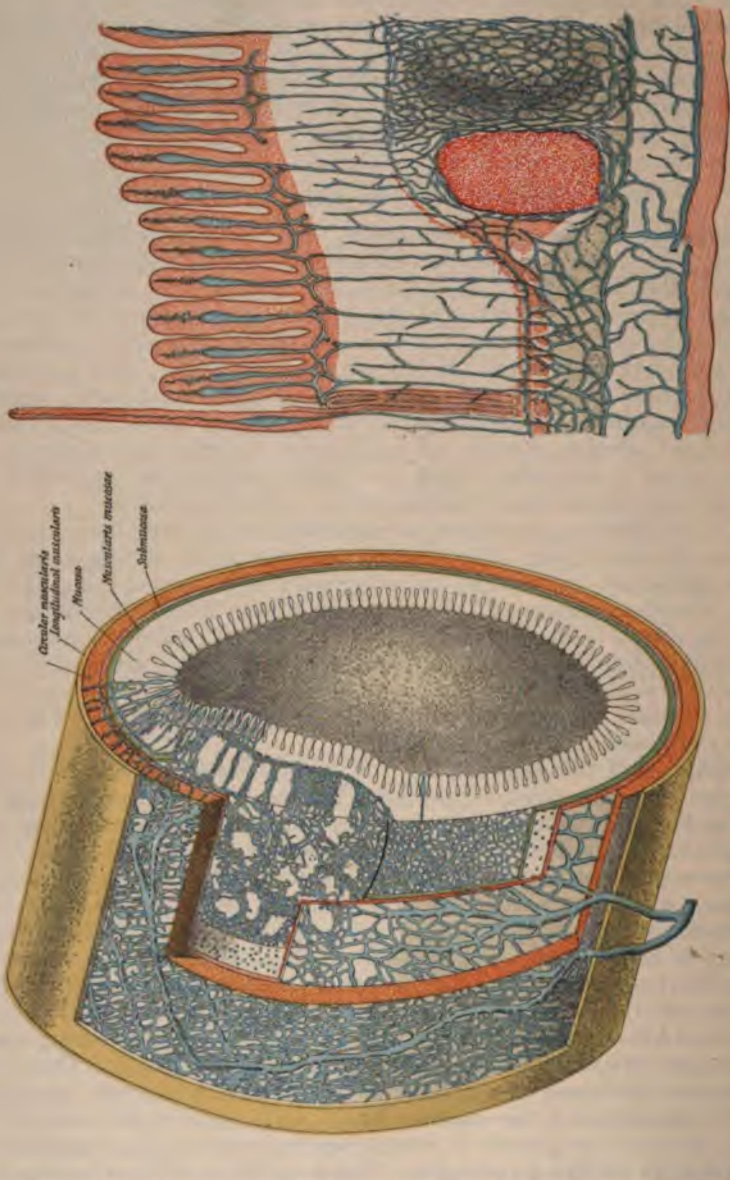


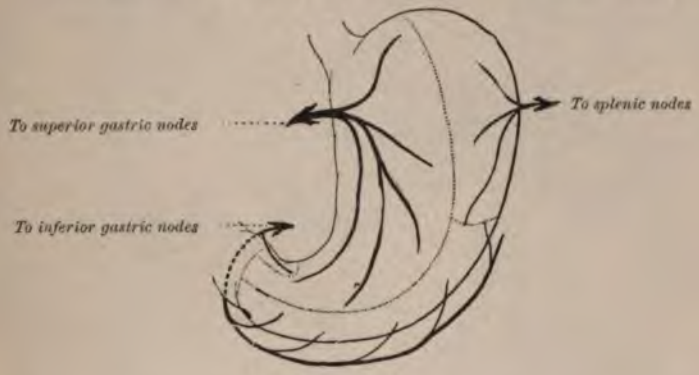
FIG. 536.—THE LYMPHATIC VESSELS OF THE INTESTINE. (After Mall.)

The lymphatics of the large intestine.—Along the ascending colon there are but few nodes on the terminal vascular arches, but the number increases along the transverse colon, especially at its two angles. These nodes, together with those along the descending and sigmoid colons, are termed the **meso-colic nodes,** and they drain partly to the superior mesenteric and partly to the inferior mesenteric nodes, their efferents following the corresponding arteries. The lymphatics of the transverse colon connect with those of the omentum; those of the descending colon are more scanty.

The lymphatics of the rectum and anus.—There are three lymphatic zones of the rectum and anus. (1) An **inferior zone,** corresponding to the anal integument, in which the capillary networks, both superficial and deep, are extremely abundant, and from which from three to five collecting ducts on either side pass to the inguinal region and end in the internal superficial inguinal nodes. (2) A **middle zone,** corresponding with the transition zone of epithelium—that is, with the mucous membrane below the columns of Morgagni. Here the network is coarse, and has its meshes arranged vertically; its ducts drain partly into nodes situated along the inferior and middle hæmorrhoidal arteries, and partly pass to nodes in the mesorectum, situated along the superior hæmorrhoidal artery and known as the **ano-rectal** nodes. (3) The **superior zone** corresponds to the remainder of the rectal mucous membrane, and contains a rich network whose collecting ducts pass to the ano-rectal glands, and thence along the superior hæmorrhoidal arteries to the inferior mesenteric nodes.

Lymphatics of the liver.—The lymphatic drainage of the liver is complicated and has great need of being entirely restudied from the standpoint of development. Its course is mainly to the cœliac nodes, but on the way it passes through a secondary group of three to six **hepatic nodes,** situated along the hepatic artery. Some of these nodes are along the horizontal part of the artery, parallel to the superior border of the pancreas, while the rest follow the artery in its vertical course along with the portal vein, and become continuous at the portal fissure with two distinct chains of nodes, one of which follows the hepatic artery and portal vein, and the other the cystic and common bile-ducts. These nodes are variable, but one constant node is at the junction of the cystic and hepatic ducts. A part of the drainage of the liver is also through the **diaphragmatic nodes.**

FIG. 537.—THE LYMPHATIC ZONES OF THE STOMACH. (Cunéo.)



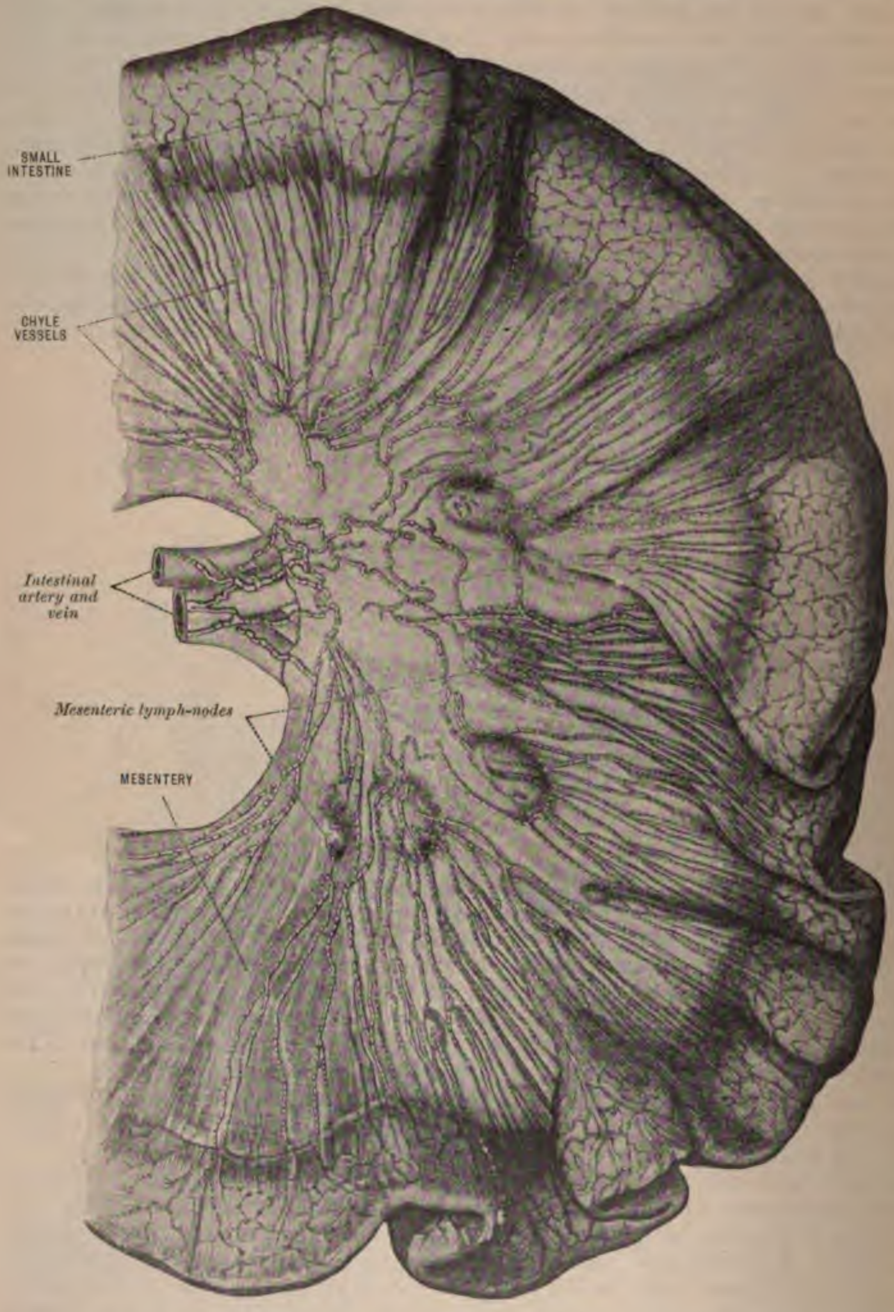
We have practically no knowledge of the lymphatic capillaries within the lobule of the liver, but there is an abundant superficial plexus (fig. 541), and a deep plexus of capillaries along the portal vein.

The superficial collecting ducts have been studied by Sappey. Those from the superior surface pass to three sets of nodes. From the posterior part ducts pass through the diaphragm with the vena cava, and end in the adjacent diaphragmatic nodes. Some of these ducts from the right lobe pass in the coronary ligament to the cœliac nodes, and some from the left lobe to the superior gastric nodes. The second set of ducts from the superior surface run over the anterior border to the hepatic nodes situated in the portal fissure. The third and most important set arises near the suspensory ligament, and passes partly backwards to the anterior medial group of nodes on the upper surface of the diaphragm, and to the nodes around the vena cava, and partly forwards to the nodes of the portal fissure.

The collecting ducts of the inferior surface pass to the nodes situated in the portal fissure, either along the artery or the bile-ducts.

Lymphatics of the pancreas.—The lymph-vessels which drain the pancreas pass to three sets of nodes:—(1) to the splenic chain leading to the cœliac nodes; (2) to nodes along the pancreatico-duodenal arteries; and (3) to the superior mesenteric nodes. The lymphatics within the pancreas are not well known.

Fig. 538.—Lymphatics of the Small Intestine. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)

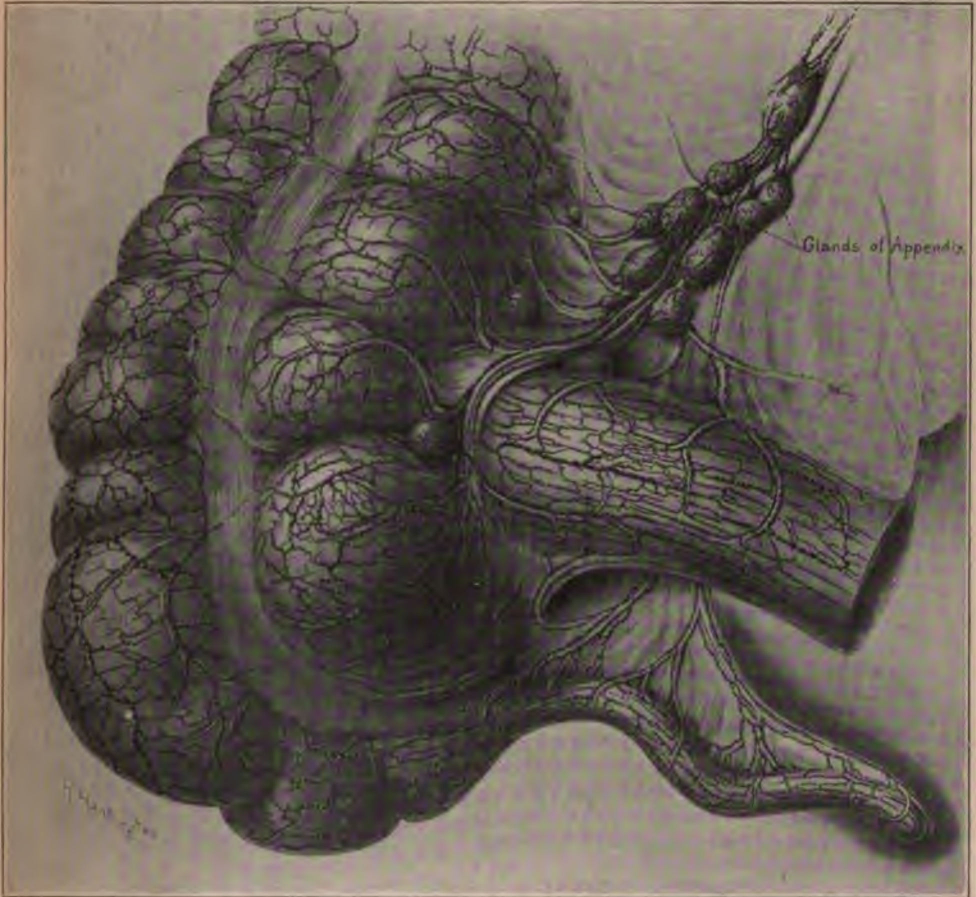

SMALL INTESTINE
CHYLE VESSELS
Intestinal artery and vein
Mesenteric lymph-nodes
MESENTERY

The **lymphatics of the spleen** (fig. 542) are found only in the form of a subcapsular plexus, there being no deep network (Mall). They pass to the **splenic nodes,** which are variable in number and are situated along the course of the splenic vessels. In addition to the spleen they drain the fundus of the stomach and a part of the pancreas.

The Lymphatics of the Excretory Organs

The lymphatics of the kidney.—In regard to the lymphatics of the kidney, we have but little knowledge. There is a capillary plexus in the capsule, though it is difficult to inject, and there is a set of deep lymphatics which, according to Sappey, may be injected by forcing water into the arteries. The ducts run to the nodes of the lumbar chain (fig. 543.) On the right side, part of the nodes concerned lie in front of the renal vein and part behind it; one of the nodes lies as far down as the bifurcation of the aorta; and one or two ducts may pass to præ-aortic nodes. On the left side the ducts end in four or five nodes of the lumbar group. The efferent ducts of these nodes pass through the diaphragm and end in the thoracic duct.

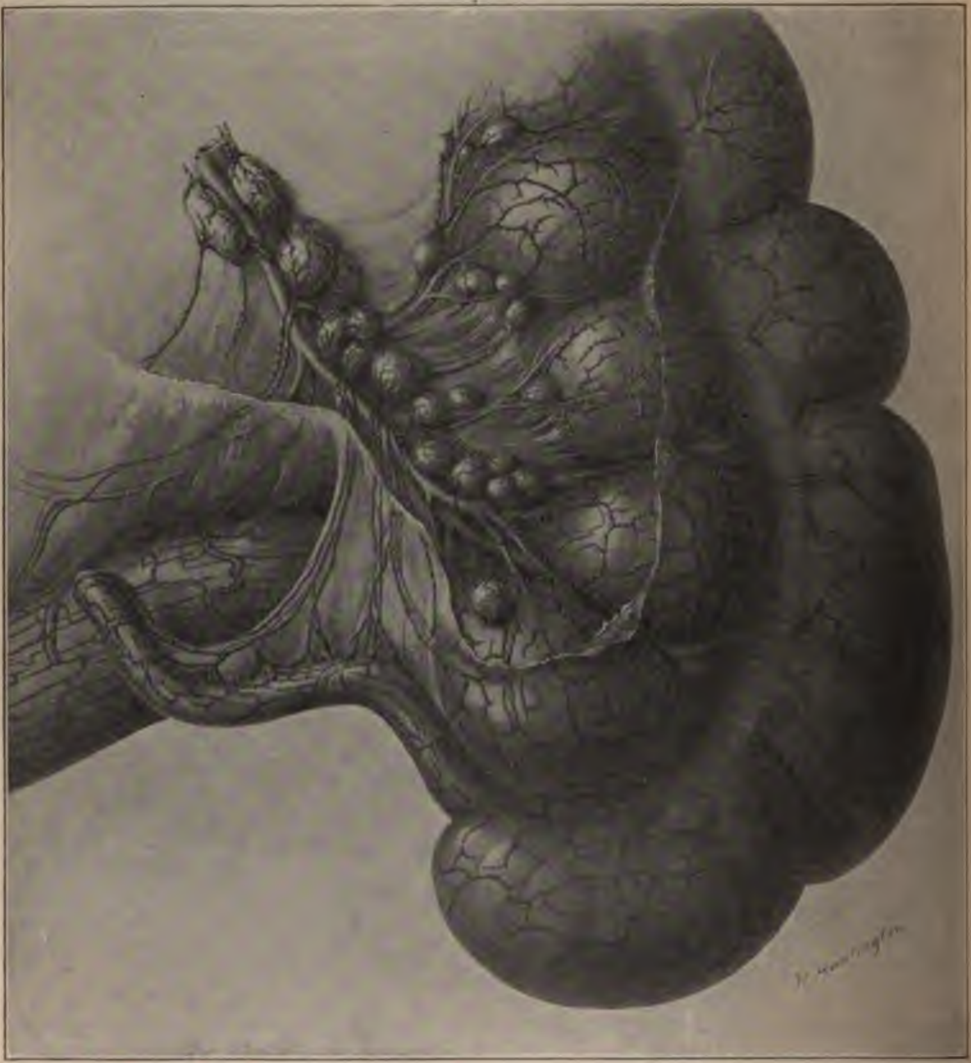
Fig. 539.—The Lymphatic Circulation of the Ileo-cæcal Region, Anterior View. (After Kelly.)



The lymphatics of the ureter.—Sakata has recently studied the lymphatics of the ureter. He found no lymphatics in either the mucosa or the submucosa, but did find them in the muscularis and in the outer surface of the duct, running with the blood-vessels. The collecting ducts pass to the inner nodes along the common iliac artery, a few also passing to the hypogastric nodes or joining with those of the bladder.

The lymphatics of the bladder.—According to Poirier, the tendency is to deny the presence of lymphatics in the mucosa of the bladder, the only network being intra-muscular, but Teichmann describes a capillary network on the inner surface, most richly developed around the opening of the urethra and in the trigone. The collecting ducts from the lower part of the anterior surface pass to a node of the external iliac group, situated near the femoral ring and the obturator nerve; those from the upper part of the anterior and posterior surfaces pass to the middle node of the middle group of the external iliac chain, and from the rest of the posterior surface they pass either to the hypogastric nodes or beyond these to the nodes at the bifurcation of the aorta (fig. 544). In this latter group end also the ducts from the neck of the bladder.

FIG. 540.—THE LYMPHATIC CIRCULATION OF THE ILEO-CÆCAL REGION POSTERIOR VIEW. (After Kelly.)



The lymphatics of the prostate.—The lymphatics of the prostate have been studied in the dog by Walker and in man by Bruhns. The occurrence of deep ducts in the prostate is doubtful. Over the surface, especially over the upper and posterior part, is a plexus of fine vessels the injection of which is difficult. The collecting ducts, six to eight on each side, pass along the prostatic artery to the nodes along the external border of the hypogastric artery. These nodes are connected with those along the external and common iliac arteries, and it is possible, *from an injection* of the prostate, to fill the entire chain of nodes as far as the renal tery. A trunk from the posterior surface runs up over the bladder and curves twards to the middle node of the middle group of the external iliac chain, and ll other ducts from the posterior surface run first downwards, pass around the ctum, and then ascend to the lateral sacral nodes. From the anterior surface a

IG. 541.—THE SUPERFICIAL LYMPHATIC NETWORK OF THE LIVER. (After Teichmann.)

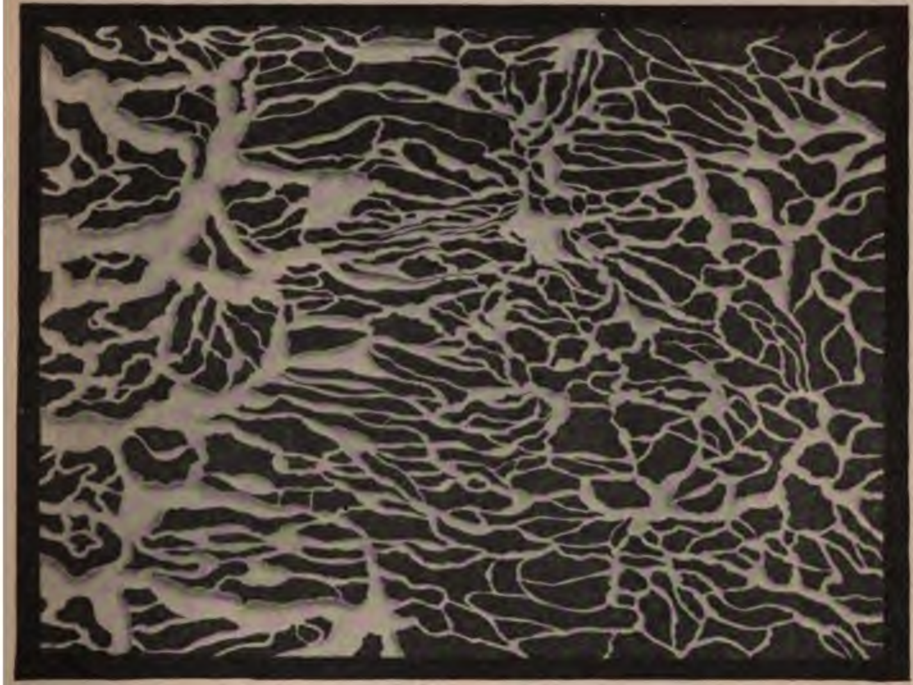
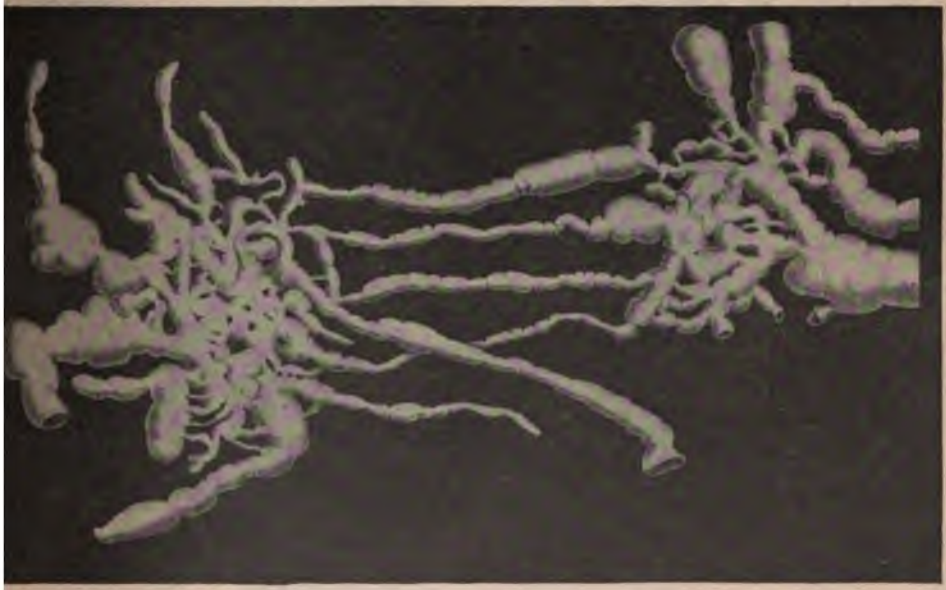


FIG. 542.—LYMPHATICS OF THE PERIPHERY OF A PIG'S SPLEEN. (After Teichmann.)



scending duct may follow the deep artery of the penis, and the internal pudic to the ypogastric nodes (fig. 545). The capillary plexus of the prostate is continuous ith that of the bladder, vas deferens, and rectum.

FIG. 543.—LYMPHATICS OF THE KIDNEY. (After Poirier and Cunéo.)

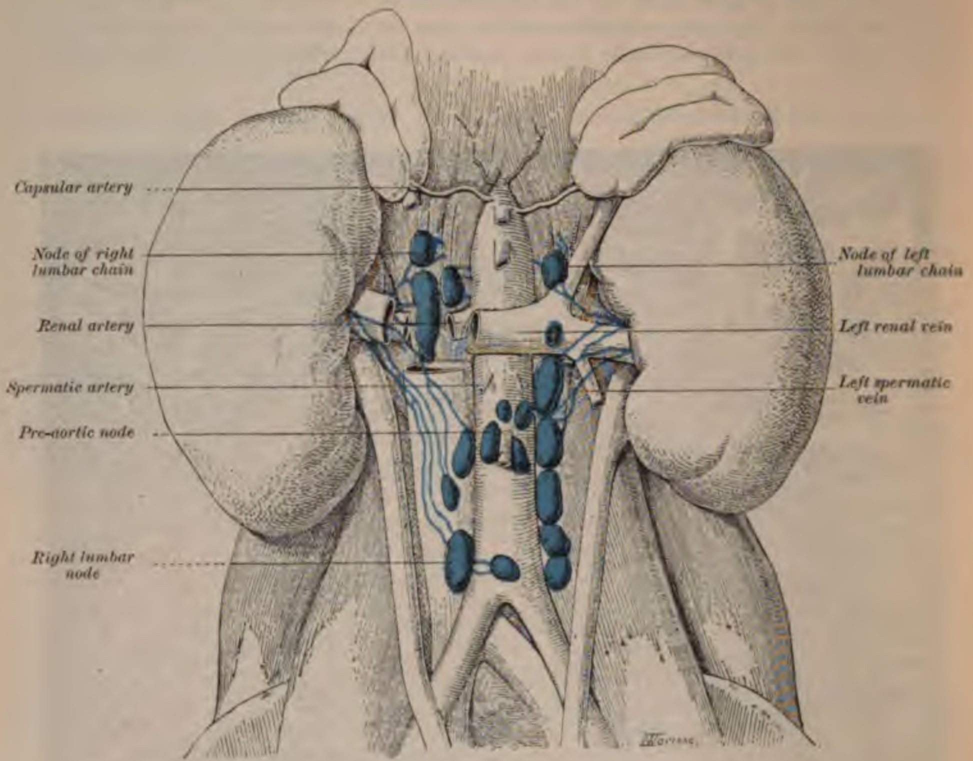
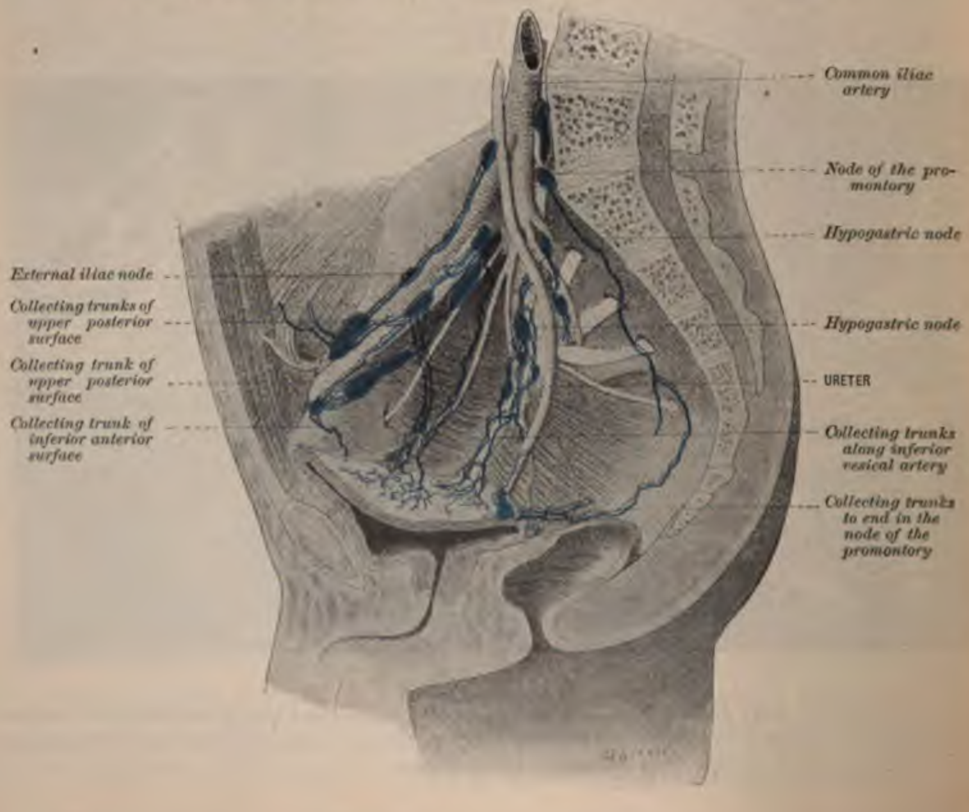

Capsular artery
Node of right lumbar chain
Renal artery
Spermatic artery
Pre-aortic node
Right lumbar node
Node of left lumbar chain
Left renal vein
Left spermatic vein

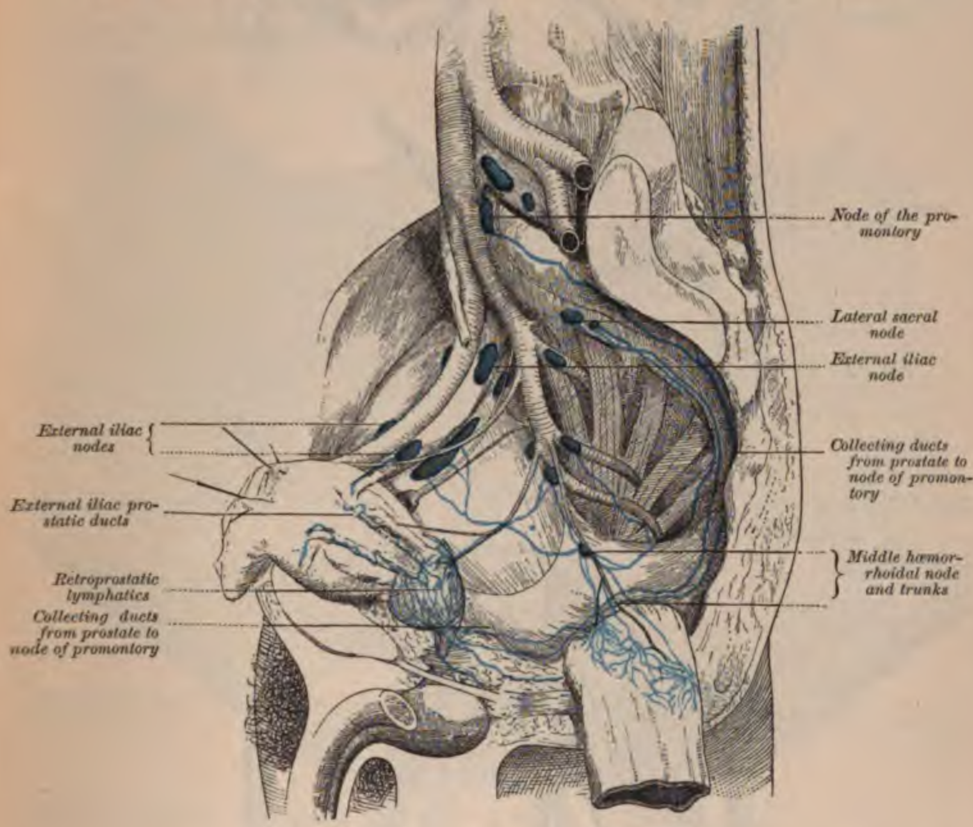
FIG. 544.—LYMPHATICS OF THE BLADDER. (After Cunéo and Marcille.)


Common iliac artery
Node of the promontory
Hypogastric node
Hypogastric node
URETER
Collecting trunks along inferior vesical artery
Collecting trunks to end in the node of the promontory
External iliac node
Collecting trunks of upper posterior surface
Collecting trunk of upper posterior surface
Collecting trunk of inferior anterior surface

The lymphatics of the urethra.—1. *In the Male.*—The capillary plexus of the urethra is in the mucous membrane. The collecting ducts from the mucous membrane of the glans follow the dorsal vein. Those from the penile and membranous portions of the urethra start from the inferior surface and curve around the corpora cavernosa, as seen in fig. 546, to join the others along the dorsal vein. These ducts run with the vein to the symphysis, where they form a plexus in which there may be some small intercalated nodes. From this plexus ducts pass in two directions:—(1) Three or four ducts, the crural trunks, pass to the deep inguinal and external iliac nodes, and (2) one duct enters the inguinal canal and ends in one of the external iliac nodes.

The ducts from the bulbar and membranous portions either follow the internal pudic artery, or pass to the symphysis and end in the external iliac nodes, or pass on to the surface of the bladder and thence to the external iliac chain. The lymphatics of the prostatic portion run with the prostatic ducts.

FIG. 545.—THE LYMPHATICS OF THE PROSTATE. (After Cunéo and Marcille.)


Node of the promontory
Lateral sacral node
External iliac node
External iliac nodes
Collecting ducts from prostate to node of promontory
External iliac prostatic ducts
Middle hæmorrhoidal node and trunks
Retroprostatic lymphatics
Collecting ducts from prostate to node of promontory

2. *In the female* the ducts of the urethra end in the external iliac and hypogastric nodes.

LYMPHATICS OF THE REPRODUCTIVE ORGANS

In the Male

The lymphatics of the external genitalia will be first described and then those of the internal organs (fig. 549).

The **lymphatics of the scrotum** form a rich plexus which has been pictured by Teichmann (fig. 509). The collecting ducts, ten to fifteen on either side, arise near the raphé and pass to the root of the penis, where some curve outwards to the superior internal superficial inguinal nodes; while others, coming from the lateral surface of the scrotum, pass to the corresponding inferior nodes.

FIG. 546.—LYMPHATICS OF THE PENILE AND MEMBRANOUS PORTIONS OF THE URETHRA. (After Cunéo and Marcille.)

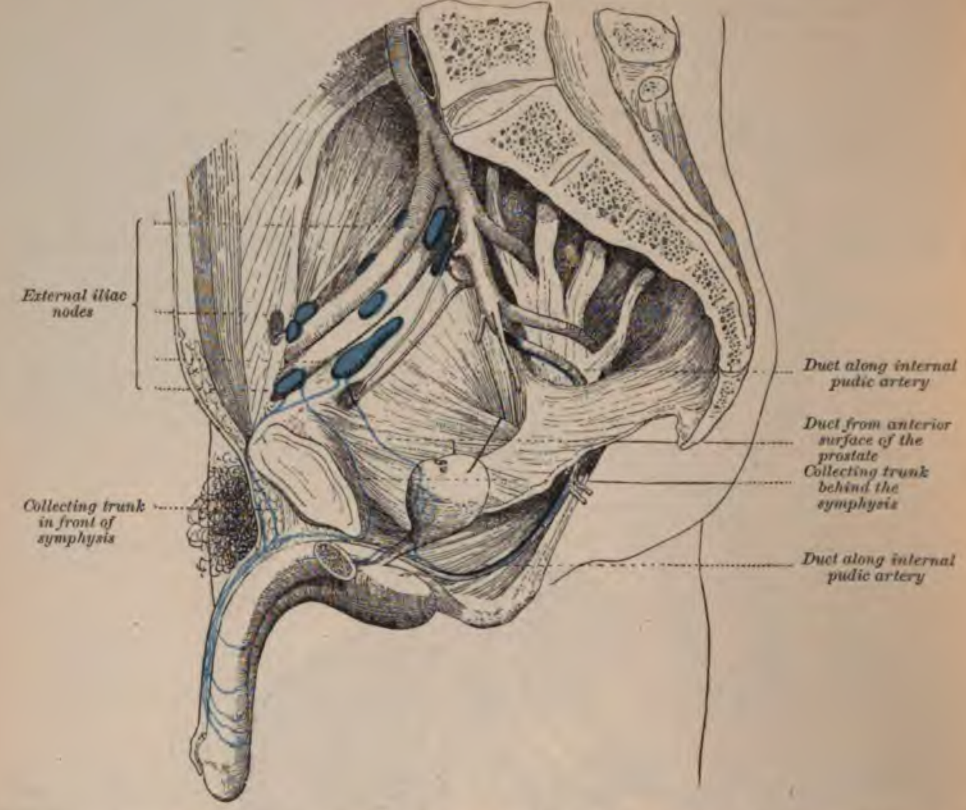
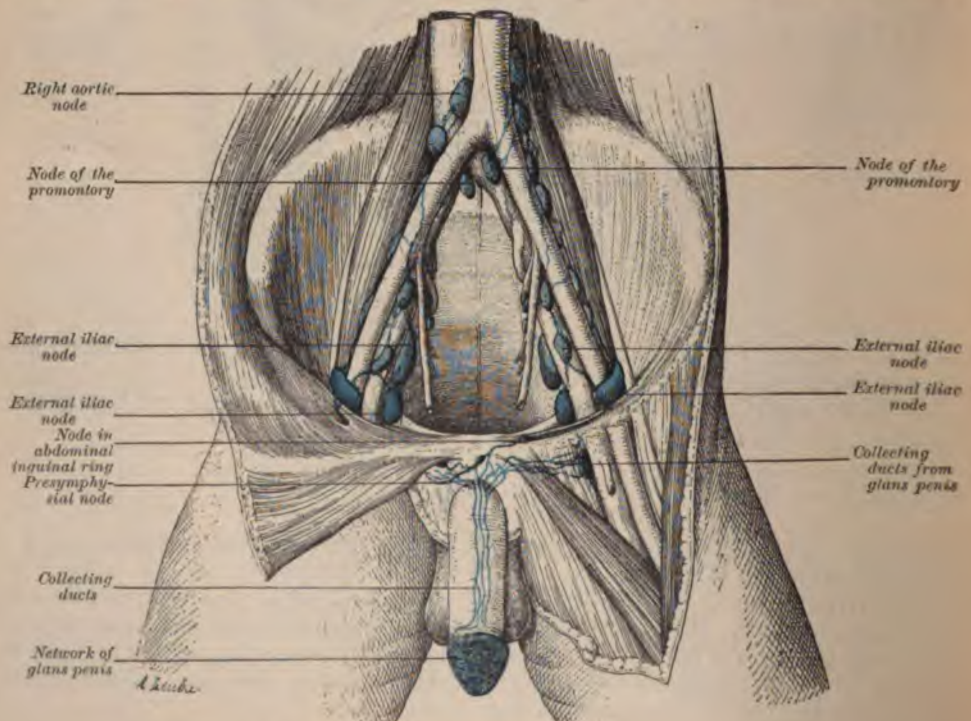

External iliac nodes
Collecting trunk in front of symphysis
Duct along internal pudic artery
Duct from anterior surface of the prostate
Collecting trunk behind the symphysis
Duct along internal pudic artery

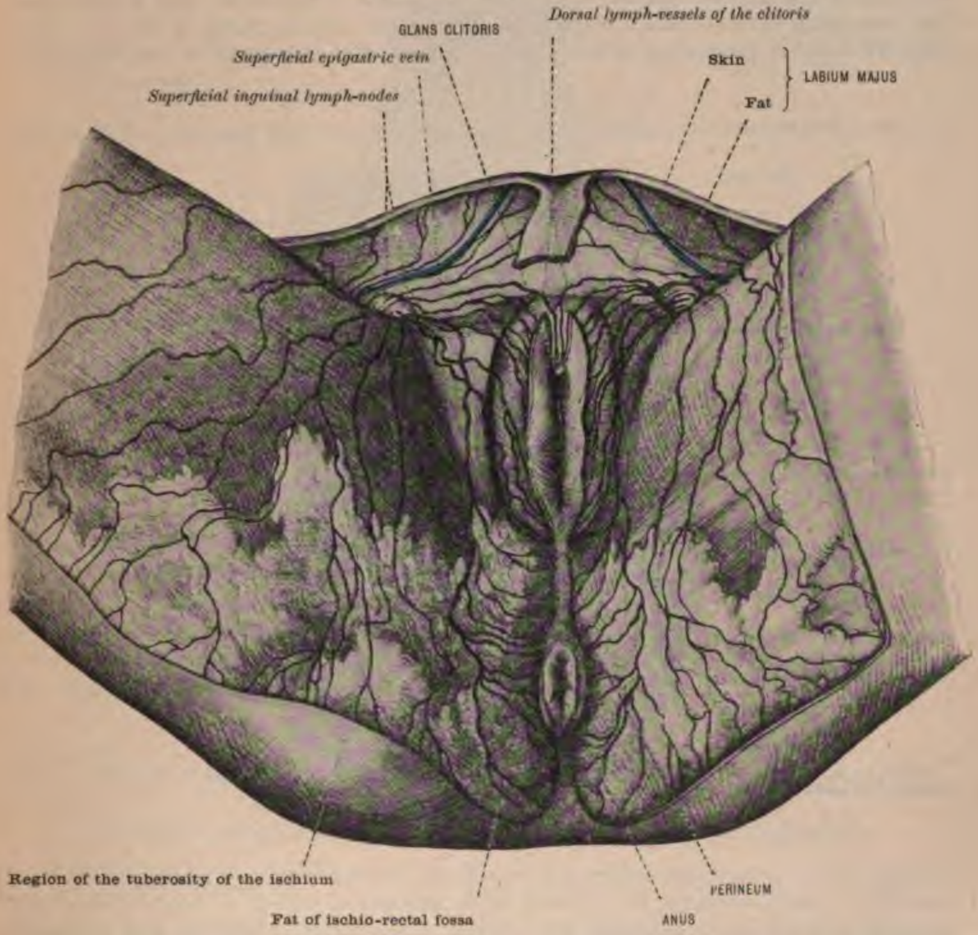
FIG. 547.—LYMPHATICS OF THE GLANS PENIS IN A NEW-BORN CHILD. (Cunéo and Marcille.)


Right aortic node
Node of the promontory
External iliac node
External iliac node
Node in abdominal inguinal ring
Presymphysial node
Collecting ducts
Network of glans penis
Node of the promontory
External iliac node
External iliac node
Collecting ducts from glans penis

The lymphatics of the penis.—(1) The cutaneous lymphatics form a plexus from which collecting ducts follow the dorsal vein and end in the superficial inguinal nodes. (2) The lymphatics of the glans form an exceedingly rich plexus from which ducts follow the dorsal vein of the penis, as described under the urethra, and end in the deep inguinal and external iliac nodes. (3) The lymphatics of the erectile structures are little known.

The **lymphatics of the testis** are both superficial and deep, the latter being exceedingly hard to inject. The collecting ducts follow the spermatic cord and artery and end in the lumbar nodes.

Fig. 548.—Lymphatics of the Perineum. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Dorsal lymph-vessels of the clitoris
GLANS CLITORIS
Superficial epigastric vein
Skin
LABIUM MAJUS
Fat
Superficial inguinal lymph-nodes
Region of the tuberosity of the ischium
PERINEUM
Fat of ischio-rectal fossa
ANUS

The lymphatics of the vas deferens and vesiculæ seminales.—In the vas deferens only the superficial set has been injected, and its ducts pass to the external iliac nodes. The plexus of the vesiculæ seminales is double, superficial and deep, and its ducts pass to the external iliac and hypogastric nodes.

In the Female

The lymphatics of the vulva.—Throughout the vulva there is an exceedingly rich, superficial lymphatic plexus, from which collecting ducts pass to the symphysis and there turn outwards to the internal superficial inguinal nodes. The fact that the capillary plexus is continuous from side to side and that there is a plexus of the ducts in front of the symphysis, makes the nodes of both sides liable to infection from a unilateral lesion.

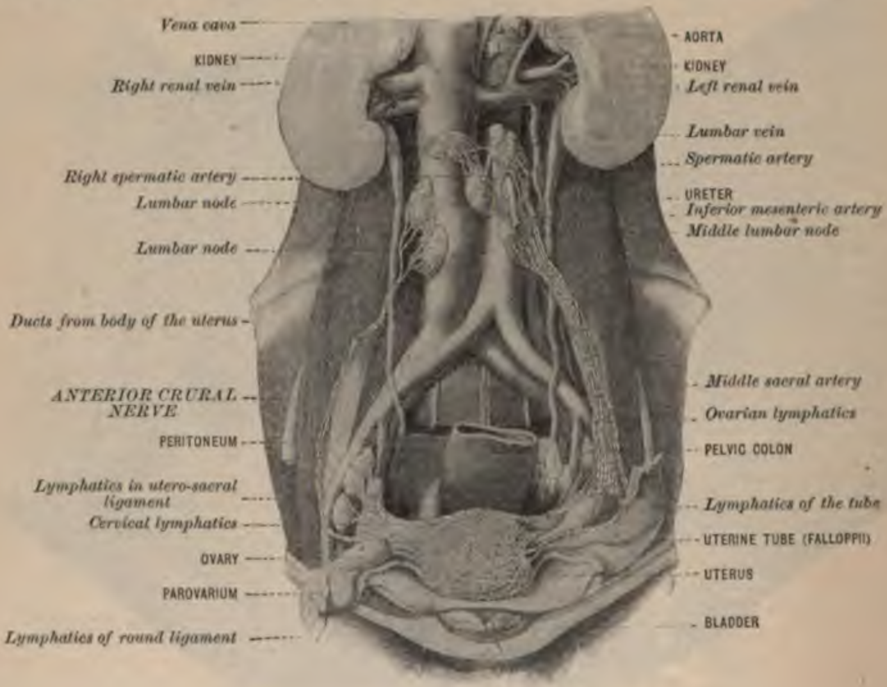
The lymphatics of the clitoris.—The lymphatics of the glans of the clitoris form an abundant network from which collecting ducts pass towards the symphysis pubis, and thence principally to the deeper inguinal nodes, one or two, however, passing through the inguinal canal to terminate in the lower external iliac nodes.

The lymphatics of the ovary.—The ovary has a remarkably rich lymphatic plexus, from which from four to six ducts leave the hilus and follow the ovarian artery to the lumbar nodes. One vessel may run in the broad ligament to the internal iliac group.

The **lymphatics of the fallopian tube** form three capillary networks from which collecting ducts run in part with those of the ovary, and in part with the uterine ducts.

The lymphatics of the uterus.—According to Poirier, the lymphatics of the uterus arise from three capillary plexuses, a mucous, a muscular, and a peritoneal. The collecting ducts from the *body of the uterus* are in three sets:—(1) Those from the fundus, consisting of four or five vessels, run outwards in the suspensory ligament of the ovary and follow the ovarian vessels to the lumbar and pre-aortic nodes. They anastomose with the lymphatics from the ovary opposite the fifth lumbar vertebra; (2) some small vessels from the fundus follow the round ligament of the uterus and terminate in the inguinal nodes; and (3) others from the body of the uterus pass laterally with the uterine vessels and terminate in the iliac nodes.

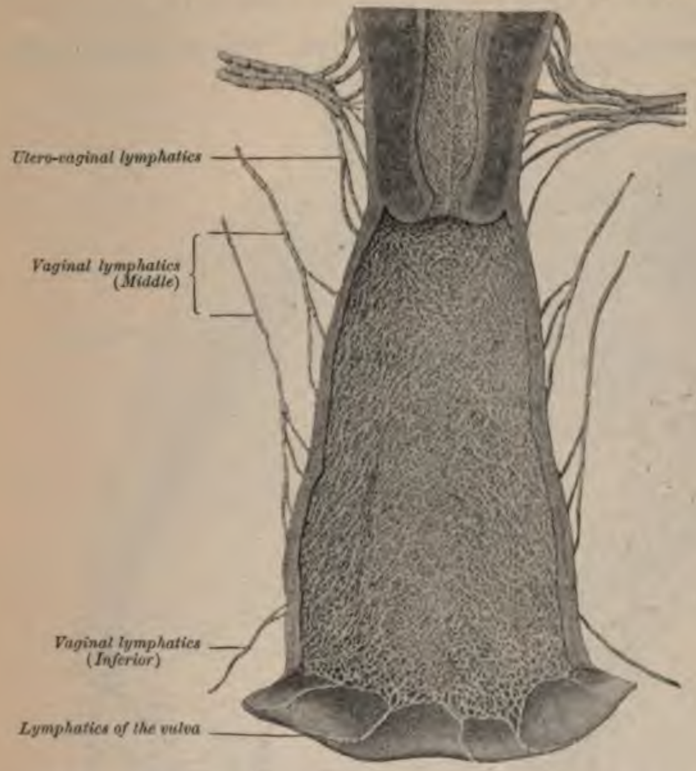
FIG. 549.—LYMPHATICS OF THE INTERNAL GENITAL ORGANS IN THE FEMALE. (After Poirier.)


Vena cava
KIDNEY
Right renal vein
Right spermatic artery
Lumbar node
Lumbar node
Ducts from body of the uterus
ANTERIOR CRURAL NERVE
PERITONEUM
Lymphatics in utero-sacral ligament
Cervical lymphatics
OVARY
PAROVARIUM
Lymphatics of round ligament
AORTA
KIDNEY
Left renal vein
Lumbar vein
Spermatic artery
URETER
Inferior mesenteric artery
Middle lumbar node
Middle sacral artery
Ovarian lymphatics
PELVIC COLON
Lymphatics of the tube
UTERINE TUBE (FALLOPPII)
UTERUS
BLADDER

The *collecting ducts from the cervix*, five to eight in number, form a large lymphatic plexus just after leaving the cervix. From this plexus run three sets of ducts. Two or three ducts pass outwards with the uterine artery in front of the ureter, and end in the external iliac nodes; a second set passes behind the ureter and ends in a node of the hypogastric group, and a third set from the posterior surface runs downwards over the vagina and then backwards and upwards to end in the lateral sacral nodes and node of the promontory of the sacrum.

The lymphatics of the vagina.—There are two lymphatic plexuses in the vagina, a superficial and deep,—the latter, the mucosa plexus, being exceedingly rich. The collecting ducts are in three groups. The superior set drains the upper third of the vagina and takes the same course as those from the lower cervical portion of the uterus; the middle set follows the vaginal artery to the hypogastric nodes; and the inferior set runs to the lateral sacral nodes and to those of the promontory. The capillary network of the lower part of the vagina is continuous with the plexus of the vulva, which drains to the inguinal nodes.

Fig. 550.—Lymphatics of the Vagina. (After Poirier.)


Utero-vaginal lymphatics
Vaginal lymphatics (Middle)
Vaginal lymphatics (Inferior)
Lymphatics of the vulva

VI. THE LYMPHATICS OF THE LOWER EXTREMITY

I. THE LYMPHATIC NODES OF THE LOWER EXTREMITY

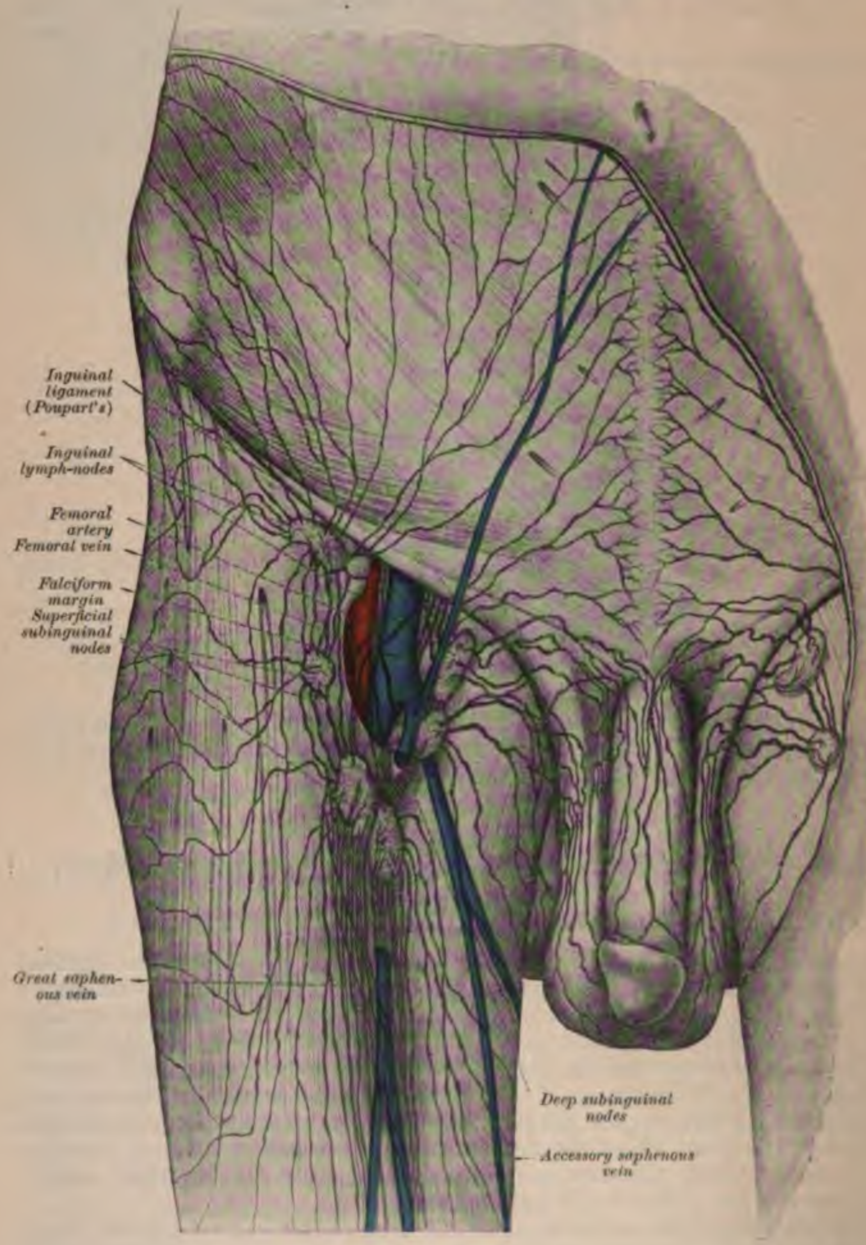
The principal group of nodes of the lower extremity is situated in the inguinal region, and hence is known as the **inguinal group.** It presents many similarities to the axillary group, although it is not quite equivalent to it developmentally. The nodes composing it are divisible into a superficial and a deep set, the former containing many more nodes than the latter, their number varying from ten to twenty, and also larger ones. Furthermore, it is convenient to divide each of these groups into an upper and a lower set, the dividing line being an arbitrary line drawn horizontally through the point where the saphenous vein pierces the fascia of the fossa ovalis. The nodes above this line are termed collectively the **inguinal nodes,** while those below it are known as the **subinguinal nodes.**

The **superficial inguinal nodes** lie along the base of the femoral trigone immediately below Poupart's ligament, superficial to the fascia lata. They receive the subcutaneous drainage of the abdominal walls, the gluteal region, and the perineal region, and their efferents descend to the fossa ovalis, which they perforate along with the saphenous vein and terminate in the lower external iliac nodes.

The **superficial subinguinal nodes** occupy the lower part of the femoral trigone and receive the entire superficial drainage of the leg, as well as a few ducts from the gluteal region and from the perineum. Their efferents pierce the fossa ovalis and pass partly to the deep subinguinal nodes and partly directly to the lower external iliac nodes.

The deep nodes.—The deep nodes are small, and vary from one to three. They lie internal to the femoral vein, the highest one being placed in the femoral ring and being of especial surgical interest in that, when enlarged, it may simulate a strangulated hernia. It is called the *node of Cloquet*, or *of Rosenmüller*. The lowest node is below the point where the lesser saphenous joins the femoral vein. These deep nodes receive the deep lymphatics of the leg, the ducts from the glans penis in the

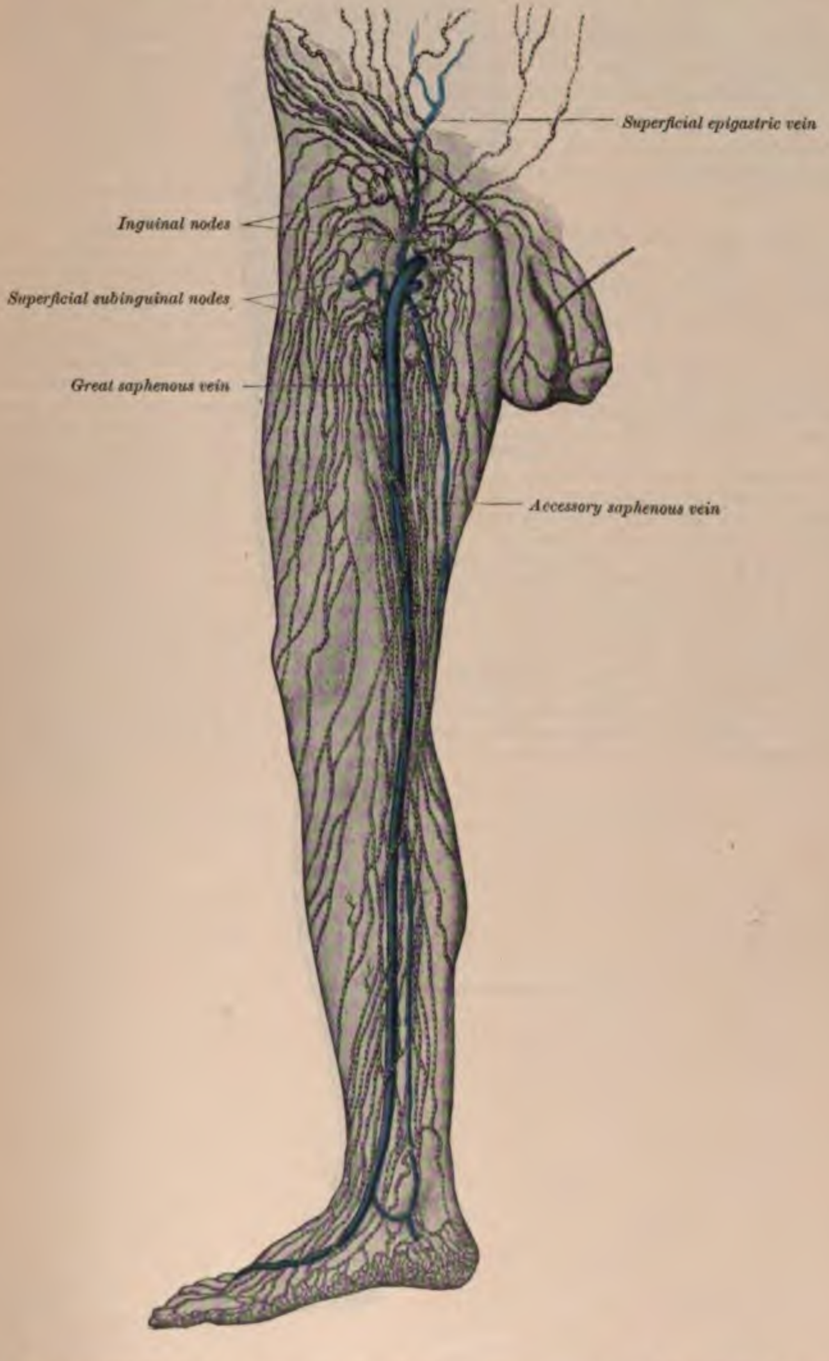
FIG. 551.—THE SUPERFICIAL INGUINAL NODES. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Inguinal ligament (Poupart's)
Inguinal lymph-nodes
Femoral artery
Femoral vein
Falciform margin
Superficial subinguinal nodes
Great saphenous vein
Deep subinguinal nodes
Accessory saphenous vein

male, and the clitoris in the female, and some of the ducts from the superficial subinguinal nodes. Their efferent ducts enter the external iliac nodes.

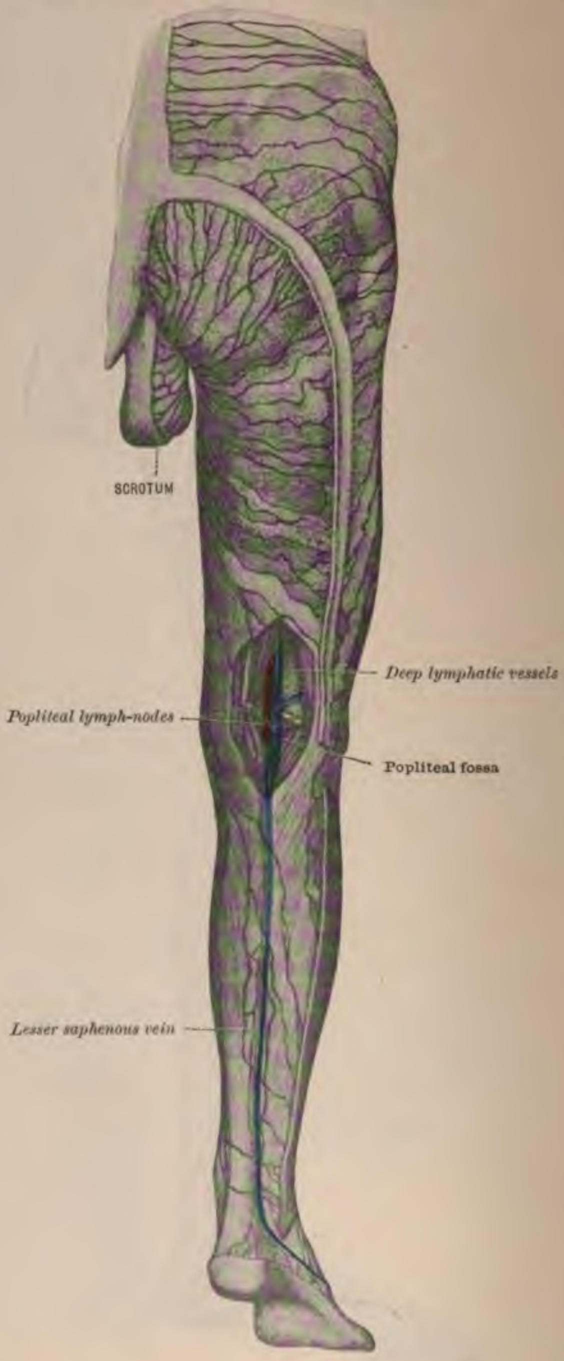
In addition to the inguinal group of nodes there are some other nodes in the lower limb situated along the course of the deep vessels. Thus there is a node in the course of the anterior tibial ducts below the knee, and there is a small group of **popliteal nodes** in the popliteal space, which are in the course of the lesser saph-

FIG. 552.—THE SUPERFICIAL LYMPHATICS OF THE LEG. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


Superficial epigastric vein
Inguinal nodes
Superficial subinguinal nodes
Great saphenous vein
Accessory saphenous vein

enous ducts, and receive the ducts which accompany the posterior tibial and peroneal vessels and those which drain the knee-joint.

FIG. 553.—THE LYMPHATICS OF THE BACK OF THE LEG. (After Toldt, "Atlas of Human Anatomy," Rebman, London and New York.)


SCROTUM
Deep lymphatic vessels
Popliteal lymph-nodes
Popliteal fossa
Lesser saphenous vein

II. THE LYMPHATIC VESSELS OF THE LOWER EXTREMITY

As in the arm, the subcutaneous capillary plexus of the leg varies greatly complexity, being most abundant in the soles of the feet. The collecting du form two main groups. The inner, larger group follows the saphenous vein, and ends in the superficial subinguinal nodes, while the outer group curves around to join the inner, partly in the leg and partly in the thigh. Two or three ducts from the heel follow the lesser saphenous vein to the popliteal space. The ducts from the upper and back of the thigh curve around on both sides to reach the superficial inguinal nodes. The ducts of the anus and perineum, as well as those from the external genitalia, except from the glans penis or the clitoris, pass to the inner nodes of the superficial inguinal group.

The deep vessels also follow the course of the arteries of the leg, those accompanying the dorsalis pedis and anterior tibial arteries coming into relation with the anterior tibial node, when it is present, and then passing backwards to join the ducts which accompany the posterior tibial and peroneal arteries. These terminate in the popliteal nodes, from which efferents follow the course of the femoral artery and terminate in the deep inguinal nodes. The deep ducts accompanying the gluteal and obturator arteries pass to the hypogastric nodes.

The development of the lymphatic system.—Lymphatic vessels were discovered in 1622 by Asellio, and the receptaculum chyli and thoracic duct by Pecquet, in 1647. From that time onwards the system was diligently studied, and in 1797 Mascagni published a comprehensive account of it, similar works by Breschet and Sappey appearing later. Improvements in methods of injection have added greatly to the knowledge of the system in recent years, and its general distribution has now been fairly satisfactorily determined.

The embryological development of the system, however, long remained obscure. Budge, in 1887, obtained an injection of spaces in the vascular area of the embryonic disc of the cheek, by forcing fluid into the extra-embryonic peritoneal cavity, and his observations were interpreted as demonstrating the origin of the lymphatics. But it was shown, in 1902, that their true origin was as outgrowths from the veins within the body of the embryo.*

The outgrowths arise in pig embryos at four points, or, according to recent observations by F. T. Lewis, from several additional ones, two of these points being near the junctions of the internal jugular and subclavian veins. From their points of origin the outgrowths gradually extend throughout the subcutaneous tissues, forming a continous network therein, and, later, all but those connected with the subclavian veins, separate from their points of origin. Later, two stems belonging to the subclavian system of outgrowths grow downwards into the thorax and accompany the aorta as a plexus to the upper part of the abdominal cavity. From this plexus the thoracic duct is eventually formed, and from it branches extend to the various viscera.

The nodes do not make their appearance until the system of vessels is well established, and are at first represented by masses of adenoid tissue in the meshes of a lymphatic network. Later the adenoid mass breaks up into smaller portions, into which blood-vessels and branches from the surrounding network penetrate, and each mass, together with the portions of the network immediately surrounding it, becomes enclosed in a connective-tissue capsule. The original adenoid tissue becomes transformed into the trabeculæ and cortical nodules of the node, while the enclosing lymphatic capillaries form its lymph-sinus.

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* This important fact was discovered by Dr. Sabin.—[Ed.]

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